THE No 1 UK MAGAZINE FOR ELECTRONICS TECHNOLOGY & COMPUTER PROJECTS

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HB7 Stirling Engine
Base measurements: 128 mm x 108 mm x 170 mm, 1 kg
Base plate: beech - Working rpm: 2000 rpm/min. (the engine has a aluminium good cooling Cylinder)
Bearing application: 10 high-class ball-bearings
Material: screw, side parts all stainless steel
Cylinder brass, Rest aluminium and stainless steel.
Available as a kit £80.75 or built £84.99
www.mamodspares.co.uk


HB9 Stirling engine
Base measurements: 156 mm x 108 mm x 130 mm, 0,6 Kg Base plate: beech Working rpm: approx. 2,000 min
Bearing application: 6 high-class ball-bearings
Material of the engine: brass, aluminium, stainless steel
running time: 30-45 min.
Available as a kit £97.75 or built £101.99
www.mamodspares.co.uk


HB10 Stirling Engine
Base measurements: 156 mm x 108 mm x 130 mm, 0,6 Kg Base plate: beech Working rpm: approx. 2,000 rpm
Bearing application: 6 high-class ball-bearings
Material of the engine: brass, aluminium, stainless steel
running time: 30-45 min
Available as a kit £97.75 or built £101.99
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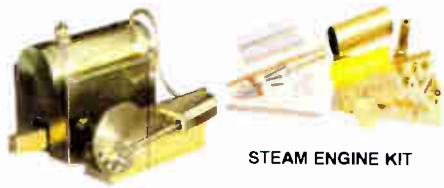
HB11 Stirling Engine
Base measurements: 156 mm x 108 mm x 130 mm, 0,7 Kg Base plate: beech
Working rpm: 2000 - 2500 rpm/min,run Bearing application: 4 high-class ball-bearings Material: screw, side parts total stainless steel Cylinder brass Rest aluminium, stainless steel.
Available as a kit £97.75 or built £101.99
www.mamodspares.co.uk

HB12 Stirling Engine
Base measurements: 156 mm x 108 mm x 130 mm, 1 Kg Base plate: beech Working rpm: 2000 - 2500 rpm/min,Bearing application: 6 high-class ball-bearings
Material: screw, side parts total stainless steel
Cylinder brass Rest aluminium, stainless steel.
Available as a kit £136 or built £140.25
www.mamodspares.co.uk

HB13 Stirling Engine
Base measurements: 156 mm x 108 mm x 150 mm, 0,75 kg Base plate: beech Working rpm: 2000 - 2500 rpm/min, Bearing application: 6 high-class ball-bearings Material: screw, side parts total stainless steel Cylinder brass
Available as a kit £97.75 or built £101.99



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Everything in the kit enables you to build a fully functional model steam engine. The main material is brass and the finished machine demonstrates the principle of oscillation. The boiler, uses solid fuel tablets, and is quite safe. All critical parts (boiler, end caps, safety vent etc.) are ready finished to ensure success. The very detailed instruction booklet (25 pages) makes completion of this project possible in a step by step manner. Among the techniques experienced are silver soldering, folding, drilling, fitting and testing. £29.70 ref STEAMKIT Silver solder/flux pack £3.50 ref SSK
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HB14 Stirling Engine
Base measurements: 156 mm x 108 mm x 150 mm, 1 kg Base plate: beech Working rpm: 2000 - 2500 rpm/min, . Incl. drive-pulley for external drives Bearing application: 10 high-class ball-bearings Material: screw, side parts total stainless steelCylinder brass Rest aluminium, stainless steel Available as a kit £140.25 or built £144.50
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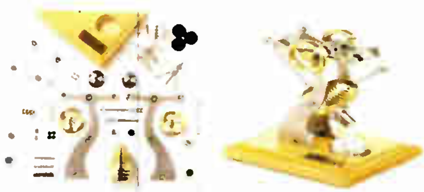

HB15 Stirling Engine
Base measurements: 128 mm x 108 mm x 170 mm, 0,75 kg Base plate: beech Working rpm: 2000 rpm/min. (the engine has a aluminium good cooling Cylinder)
Bearing application: 6 high-class ball-bearings
Material: screw, side parts total stainless steel
Cylinder brass Rest aluminium, stainless steel
Available as a kit £97.75 or built £102
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HB16 Stirling Engine
Base measurements: 128 mm x 108 mm x 170 mm, 1 kg Base plate: beech Working rpm: 2000 rpm/min. (the engine has a aluminium good cooling Cylinder)
Bearing application: 10 high-class ball-bearings
Material: screw, side parts total stainless steel
Cylinder brass Rest aluminium, stainless steel.
Available as a kit £140.25 or built £144.50

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The 2kW wind turbine is supplied as the following kit: turbine generator 48v three taper/ twisted fibreglass blades & hub 8m tower (four x 2m sections) guylines / anchors / tensioners / clamps foundation steel rectifier 2kW inverter heavy-duty pivot tower. £1,499

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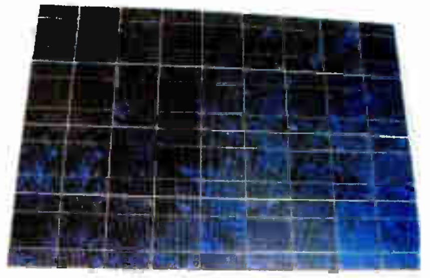

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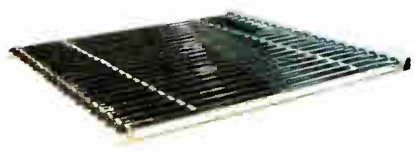
We stock a range of solar photovoltaic panels. These are polycrystalline panels made from wafers of silicon laminated between an impact-resistant transparent cover and an EVA rear mounting plate. They are constructed with a lightweight anodised aluminium frame which is predrilled for linking to other frames/roof mounting structure, and contain waterproof electrical terminal box on the rear. 5 watt panel £29 ref 5wnav 20 watt panel £99 ref 20wnav 60 watt panel £249 ref 60wnav. Suitable regulator for up to 60 watt panel £20 ref REGNAV



Solar evacuated tube panels
(20 tube shown) These top-of-the-range solar panel heat collectors are suitable for heating domestic hot water, swimming pools etc - even in the winter! One unit is adequate for an average household (3-4people), and it is modular, so you can add more if required. A single panel is sufficient for a 200 litre cylinder, but you can fit 2 or more for high water usage, or for heating swimming pools or underfloor heating. Some types of renewable energy are only available in certain locations, however free solar heating is potentially available to almost every house in the UK! Every house should have one -really! And with an overall efficiency of almost 80%, they are much more efficient than electric photovoltaic solar panels (efficiency of 7-15%). Available in 10, 20 and 30 tube versions. 10 tube £199, 20 tube £369, 30 tube £549. Roof mounting kits (10/20 tubes) £12.50, 30 tube mounting kit £15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This 30 in 1 electronic kit includes an introduction to electrical and electronic technology. It provides conponents that can be used to make a variety of experiments including Timers and Burglar Alarms. Requires: 3 x AA batteries. £15.00 ref BET1803
**AM/FM Radio** This kit enables you to learn about electronics and also put this knowledge into practice so you can see and hear the effects. Includes manual with explanations about the components and the electronic principles. Req's: 3 x AA batts. £13 ref BET1801
This **40 in 1 electronic kit** includes an introduction to electrical and electronic technology. It provides components that can be used in making basic digital logic circuits, then progresses to using Integrated circuits to make and test a variety of digital circuits, including Flip Flops and Counters. Req's: 4 x AA batteries. £17 ref BET1804
The **75 in 1 electronic kit** includes an nintroduction to electrical and electronic technology. It provides components that can be used to make and test a wide variety of experiments including Water Sensors, Logic Circuits and Oscillators. The kit then progresses to the use of an integrated circuit to produce digital voice and sound recording experiments such as Morning Call and Burglar Alarm. Requires: 3 x AA batteries. £20 ref BET1806
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ISSN 0262 3617

PROJECTS . . . THEORY . . .
NEWS . . . COMMENT . . .
POPULAR FEATURES . . .

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# EPE EVERYDAY PRACTICAL ELECTRONICS

INCORPORATING ELECTRONICS TODAY INTERNATIONAL

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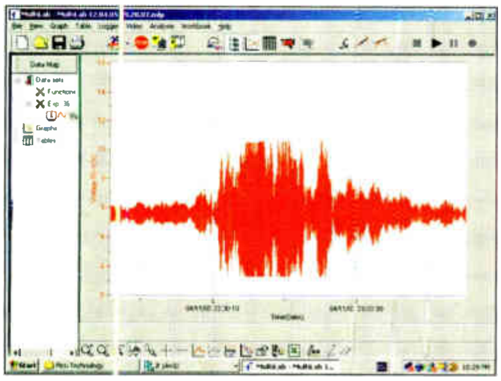



## Projects and Circuits



## Series and Features



## Regulars and Services





*Our November 2007 issue will be published on Thursday, 11 October 2007, see page 80 for details.*

## Hot New Products!

Here are a few of the most recent products added to our range. See website or join our email Newsletter for all the latest news.

**Embedded Engineer's Development Tool (Atmel 89S & AVR)**

At last the development tool kit for Atmel 89S & AVR devices that engineers have dreamed of has arrived. The kit includes a Built-in ISP Programmer, Target Section, Interfacing Board, Cables, eBook with codes, e-Learning Software with explanation and CD all in one neat package. Devices covered include 89S51, 89S52, 89S8253, mega8515, mega8535, mega8, mega16 & mega32.

**Features**

Designed for working professionals, students and product development companies

You can connect any device like LCD, 7-Segment, Sensors, Switches to any desired port of the microcontroller

No dedicated connections between microcontroller and the interfacing sections. You can connect anything, anywhere

e-Learning Tutorial and Book are included

Once you start using the kit, you will should never feel the need to attend any trainings because it is simple to use and all concepts are explained in simple language using the tutorial and book

Includes 89S51, 89S52, ATmega8, ATmega16, ATmega32 In-circuit Programmer - no need to buy a separate programmer!

No ZIF Sockets. No hassle inserting and removing microcontroller to program

In-circuit programming reduces development time as you do not need to move microcontroller

**Contents**

- In circuit programmer for 89S and AVR series (supports up to Atmega128)
- 89S51/52 target section
- ATmega8 Target section
- ATmega16/32 Target section
- Switches
- Relays
- LEDs
- 7 Segment Displays
- 16 X 2 LCD
- ADC
- Motor Driver
- RS232
- EEPROM
- Cables
- Connectors
- Serial Port Lead
- e-Learning Software
- e-Datasheets
- HandyProg Programming software
- IDEs for code writing
- Application source code

Assembled Order Code: EEDT - **£89.95**

Most items are available in kit form (KT suffix) or assembled and ready for use (AS prefix).

## Motor Speed Controllers

Here are just a few of our controller and driver modules for AC, DC, Unipolar/Bipolar stepper motors and servo motors. See website for full details.

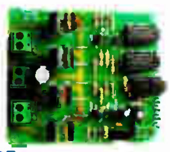
**DC Motor Speed Controller (100V/7.5A)**

Control the speed of almost any common DC motor rated up to 100V/7.5A. Pulse width modulation output for maximum motor torque at all speeds. Supply: 5-15Vdc. Box supplied. Dimensions (mm): 60Wx100Lx60H.
Kit Order Code: 3067KT - **£13.95**
Assembled Order Code: AS3067 - **£21.95**

**PC / Standalone Unipolar Stepper Motor Driver**

Drives any 5, 6 or 8-lead unipolar stepper motor rated up to 6 Amps max. Provides speed and direction control. Operates in stand-alone or PC-controlled mode. Up to six 3179 driver boards can be connected to a single parallel port. Supply: 9Vdc. PCB: 80x50mm.
Kit Order Code: 3179KT - **£12.95**
Assembled Order Code: AS3179 - **£19.95**

**Bi-Polar Stepper Motor Driver**



Drive any bi-polar stepper motor using externally supplied 5V levels for stepping and direction control. These usually come from software running on a computer.
Supply: 8-30Vdc. PCB: 75x85mm.
Kit Order Code: 3158KT - **£17.95**
Assembled Order Code: AS3158 - **£27.95**

**Bidirectional DC Motor Controller**

Controls the speed of most common DC motors (rated up to 32Vdc/10A) in both the forward and reverse direction. The range of control is from fully OFF to fully ON in both directions. The direction and speed are controlled using a single potentiometer. Screw terminal block for connections.
Kit Order Code: 3166v2KT - **£17.95**
Assembled Order Code: AS3166v2 - **£27.95**

**AC Motor Speed Controller (700W)**

Reliable and simple to install project that allows you to adjust the speed of an electric drill or single phase 230V AC motor rated up to 700 Watts. Simply turn the potentiometer to adjust the motors RPM. PCB: 48x65mm. Not suitable for use with brushless AC motors.
Kit Order Code: 1074KT - £12.95
Assembled Order Code: AS1074—£18.95
Box Order Code 2074BX - £5.95

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**Also available** - 30-in-1 **£16.95**, 130-in-1 **£39.95** & 300-in-1 **£59.95** (details on website)

## Tools & Test Equipment

We stock an extensive range of soldering tools, test equipment, power supplies, inverters & much more - please visit website to see our full range of products.

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**Technical Specifications**

DC voltage: 200mV-1000V • AC voltage: 2V-750V • DC current: 20mA-10A • AC current: 20mA-10A • Resistance: 200Ω-200MΩ • Capacitance: 2nF-20uF • Temperature: 0 - 1000°C • Max display: 1999

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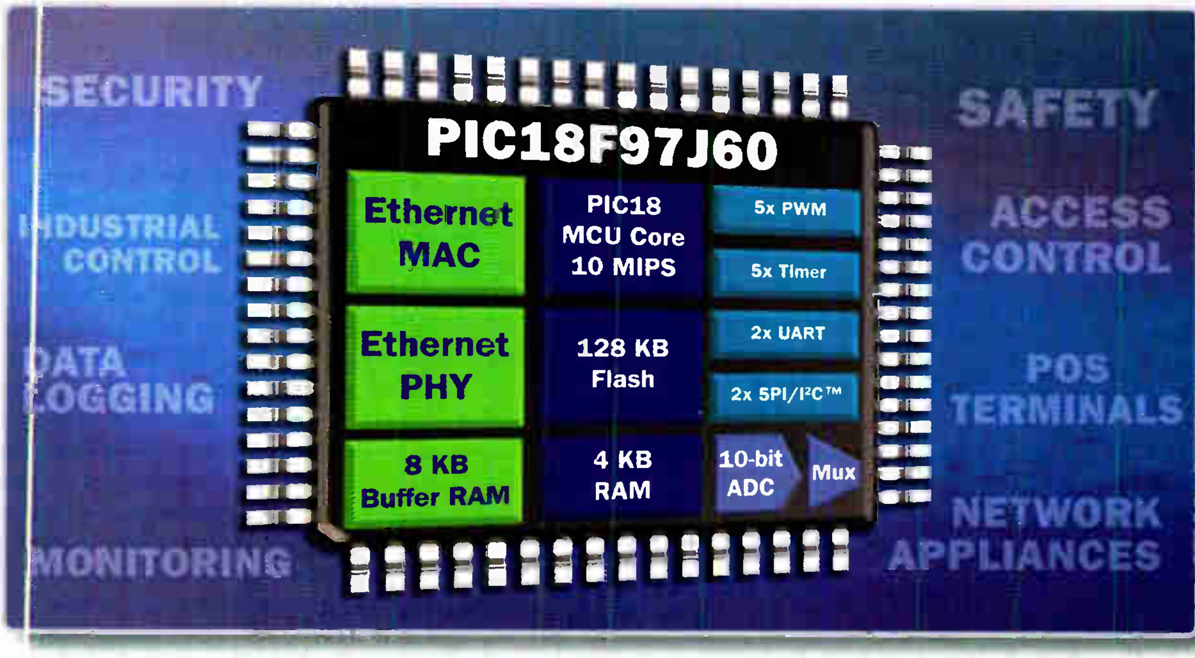
# Embedded Ethernet Solutions

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   Our TCP/IP stack is available in source code for flexible and optimized code size.
3. **Check out our low-cost Ethernet tools**
   Evaluate the PIC18F97J60 family with the ***PICDEM.net™ 2 Demonstration Board*** (DM163024) at **www.microchipDIRECT.com.**

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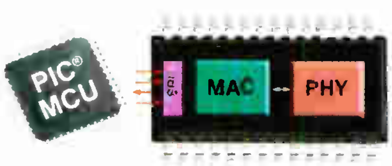
|---|---|---|---|
| PIC18F97J60 | 100 | 128 | 10-BaseT Ethernet<br>12 KB RAM<br>(8 KB dedicated Ethernet)<br>5x 16-bit timers<br>10-bit ADC, 16 channels<br>analog comparators<br>2 UART with LIN protocol<br>2 SPI, 2 I²C™<br>Industrial Temperature<br>-40° to +85°C |
| PIC18F87J60 | 80 | 128 | |
| PIC18F67J60 | 64 | 128 | |
| PIC18F96J65 | 100 | 96 | |
| PIC18F86J65 | 80 | 96 | |
| PIC18F66J65 | 64 | 96 | |
| PIC18F96J60 | 100 | 64 | |
| PIC18F86J60 | 80 | 64 | |
| PIC18F66J60 | 64 | 64 | |
| ENC28J60 | 28 | 8K RAM | MAC, PHY, SPI Interface |

***Or you may consider...***

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## Saving the planet...

This month we present the *Standby Power Saver*. With much noise (hot air!) being generated about the cost to the environment of carbon emissions this is a topical subject. If we all turned off all of our appliances, instead of leaving them on standby, the power saved would be around 1TWh (one terrawatt hour – that is 1 with 12 zeros or $10^{12}$) annually. With our fossil fuels running out it is a very significant saving. Of course, the Power Saver uses energy and its construction also uses energy, so we could never save the whole 1TWh, but every little helps!

The other area raising interesting arguments on power saving is the use of compact flourescent lamps (CFLs) and various views on this have been aired in *EPE* over the last few months; the subject is addressed again this month in our *Banning The Bulb* article.

## ...or not!

I personally do not believe that the carbon emissions we generate are having any effect on the environment. A number of scientific studies do not support the global warming bandwaggon – it may be getting warmer, but not because we take plane flights or run our cars, or turn on our TVs etc.

As John Becker shows in the *Standby Power Saver* article, the 'standby' electricity consumption in a year is equivalent to 1.4 million long haul flights, so maybe we should be protesting the equipment manufacturers and the government to legislate against 'standby' in its present form, rather than protesting airport expansion. Global travel is never going to go away, but we can easily do something to save electrical energy, as our project demonstrates.

As a matter of fact, the emissions from the cattle we breed for milk and beef do far more 'harm' than travel. Livestock are responsible for around 18 percent of 'greenhouse gasses' – more than all forms of travel put together, so maybe we should all become vegans!

Mike Kenward

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**PROJECTS AND CIRCUITS**

All reasonable precautions are taken to ensure that the advice and data given to readers is reliable. We cannot, however, guarantee it and we cannot accept legal responsibility for it.
A number of projects and circuits published in *EPE* employ voltages that can be lethal. **You should not build, test, modify or renovate any item of mains-powered equipment unless you fully understand the safety aspects involved and you use an RCD adaptor.**

**COMPONENT SUPPLIES**

**We do not supply electronic components or kits** for building the projects featured, these can be supplied by advertisers.
**We advise readers to check that all parts are still available before commencing any project in a back-dated issue.**

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# News . . .

A roundup of the latest Everyday News from the world of electronics

## Printing Without Wires

**Has the security problem been cracked? Barry Fox examines the question.**

Printing without wires is not as easy as it sounds. The system must ensure privacy for document printing and no risk of someone in the street or next door eavesdropping data or hijacking the printer, accidentally or maliciously, to waste paper and ink by printing hundreds of pages.

Bluetooth is reasonably secure because the signal is weak and does not leak through walls. But this makes it well nigh useless for home or office wireless networking.

WiFi to the IEEE 802.11 family of standards uses much stronger signals which reach several hundred metres, and through some walls. But WiFi is notoriously insecure unless the owner sets WEP or WPA password keys on all networked equipment. Firewalls, antivirus and anti-spyware protection can then block communication unless correctly set up. So many people still use WiFi without security.

Lexmark claims to have cracked the problem of security with simplicity in a new range of seven printers, all with built-in WiFi. Set-up is by a Lexmark software CD which is run on the PC while connected to the printer by USB cable. The PC sends password instructions down the cable to the printer, which stores the instructions in non-volatile memory. The USB cable can then be disconnected and the PC and printer thereafter communicate securely by WiFi.

So the long-reach signals cannot be intercepted by a third party. Surprisingly, the new printers cannot be connected by WiFi to one of the new generation of WiFi cameras. Nor do they have built-in Bluetooth for wireless connection to a camera phone.

To print pictures from a camera, the owner must resort to the traditional techniques of connecting the printer to a PC by USB cables, or using the PictBridge standard for connecting the printer direct to a camera by USB cable, or taking the memory card from a camera and slotting it into the printer's card reader.

Lexmark was unable to say whether a future firmware upgrade will be available to let the new printers connect wirelessly to a WiFi camera.

## Pico Trigger Power

Pico Technology have just added a set of advanced trigger types to the PicoScope 5000 series of scopes to make it easier to trigger on complex waveforms.

The PicoScope 5000 series PC Oscilloscopes are Pico's top-performing scopes, with the world's fastest real-time sampling rate, for a USB PC scope, of 1GS/s. This, together with a probe-tip bandwidth of 250MHz, makes them ideal for use with high-speed analogue and digital signals. The scope's huge memory buffer – either 32M or 128M samples depending on the version – ensures that the high sampling rate can be used on a wide range of timebases without losing detail.


The new advanced trigger types are part of a continuing programme of upgrades for the PicoScope 5000 series scopes, which has recently seen the addition of an auto-setup command and a new spectrum view. The new trigger types are dual-edge, window, pulse-width, drop-out, interval and logic triggering. Window triggering detects when signals go into or out of a given range, so is useful for finding overvoltages. Pulse-width triggering can recognise short or long pulses, so it helps you find glitches and timing violations.

The drop-out trigger finds the moment when a repetitive signal, such as a clock, goes dead. Interval triggering detects when two successive clock edges fail to meet a timing condition. Finally, logic triggering lets you trigger on practically any combination of up to four input levels or voltage windows.

If you're troubleshooting digital signals, you will be able to use these new trigger types to obtain a stable display of complex digital waveforms, such as serial data streams and control signals. The PicoScope 5000 series scopes are ideal instruments for digital troubleshooting because of their high sampling rate and large buffer size, which when used together allow you to capture long-duration snapshots with high time resolution.

The latest PicoScope 6 upgrade with advanced triggering is available now for download, free of charge, from the Pico Technology website at **www.picotech.com**. Call Pico on +44 (0) 1480 396 395 for more details.

# Microchip Launches Semiconductor Wiki

Microchip has announced ICwiki – a website that enables engineers to collaborate and share information related to semiconductor products, applications and best practices. Using Wiki technology, participants can change content on the site and participate in web logging ('blogging'), voting and messaging. ICWiki is available in several different languages, including English, Chinese, Japanese, French, German, Italian, Portuguese, Russian and Spanish.

Following recent trends toward online social networking, ICwiki was designed to help engineers share knowledge about designs and applications, as well as helping university students gain access to knowledge that can help bridge their transition from academia to industry.

Participants can work together in either public or private blogs via the site's Group Decision Support Systems (GDSS) feature. Subject areas on the new Wiki include particular market areas such as automotive, home appliances and robotics; functional topics such as algorithms, oscillators, PCB layout best practices and signal conditioning; and product topics such as microcontrollers, Digital Signal Controllers (DSCs), analogue and memory products.


The new ICwiki, while promoting links between academia and industry, also forms an important part of the 'University of Microchip'. This is Microchip's education and training program, not only supporting universities all around the world, but also encompassing training provision in Regional Training Centres (RTCs) worldwide, at Microchip's MASTERs conferences and in online Design Centers.

For further information, visit Microchip's Web site at (**www. microchip .com/ICwiki**).

## *Robotics Research Fosters Wales and French Connection*

*Robots that are programmed to explore underwater and send images to the surface were among the research projects tackled by students from France who have spent four months working closely with lecturers at the University of Wales, Newport.*

*The four students, from Ecole Nationales Superieure de Mecanique et des Microtechniques (L'ENSMM) in Besancon in Eastern France, came to Wales to work on a series of ongoing projects at the Mechatronics Research Centre in the University's Departments of Computing and Engineering.*

*"It was a pleasure to welcome these overseas students, whose work on a number of diverse robotics-based projects will enable us to continue our research by providing us with the hardware and software to try new control systems and artificial intelligence algorithms," said computing lecturer Dr Christopher Tubb.*

*"The students came here on the SOCRATES programme which supports European cooperation in key areas, including new technologies. They have been working with the Department of Computing on projects that make up the final year module element of the university's degree programme and also meet the requirements of their programme of study, which involves an internship with an industrial partner.*

*"One of the students, Antoine Faucher, carried out work on a new project we are looking at, possibly in conjunction with the local authority, which involves Human Power Vehicles (HPVs). The local authority is interested both from a recycling and an in town without the car perspective, as we will probably be using old bikes and other recycled material. This project is linked to the idea that within an urban environment the use of human powered vehicles can provide personal transport in a clean, quiet and safe manner".*

*For further information browse* ***www3.newport.ac.uk/news/displayStory.aspx?story_id=163****.*

## MERG's 40th Anniversary

The Model Electronic Railway Group (MERG) is celebrating its 40th anniversary. Its Summer Journal just received reflects this.

As usual, the Journal reports the activities of the various groups around the southern UK. Features focus on model railways in general, including a PIC-based design for reading track occupancy into a PC, complete with the ASM code. Other electronic add-ons are discussed as well. It's good to see that matters relating to DCC controllers are coming more to the fore in the UK.

The Group also report that they have over 900 members and new ones are joining at the rate of 15 per month. They believe that this is due to the huge interest in DCC and the large reservoir of resources the Group is able to offer modellers.

To find out more about MERG, contact the Membership Secretary, Brian Martin, 40 Compton Avenue, Poole, Dorset BH14 8PY. Tel: 01202 701930. Email: memsec@merg.info.

## TV SURGERY BOOKINGS

The Science Photo Library tell us that it is now posssible to book a doctor's appointment in the UK through your digital TV. More than 1100 doctor's surgeries across the UK are offering booking and cancellation services through a TV, after a two-year pilot study showed that the method reduced the number of missed appointments, saving time for GPs and support staff.

The system is planned to expand in the near future, with the ability to order repeat prescriptions being added. The service is available through an interactive button on a digital TV remote control.

The Science Photo Library is at 327-329 Harrow Road, London W9 2RB. Tel: 020 7422 1100. Web: **www.sciencephoto.com**.

## EOCS Magazine

*We have been sent the latest quarterly issue of the magazine of the Electronic Organ Constructors Society (EOCS). Just one item that it's interesting to highlight here is an article on copying and restoring recording tapes. This news writer recently tried to buy some more quarter inch recording tape, and failed. Few shops knew what was wanted. None had product. This article relates to copying tapes to CD.*

*If you are interested in constructing electronic organs and related items, browse* ***www.eocs.org.uk****, or contact Ron Coates, Treasurer/Secretary EOCS, 2 Boxhill Way, Seaford, Sussex BN25 3QB. Tel: 01323 894909.*

# Keeping The Lights On

**The chaos predicted by doomsayers for when fossil fuel resources run out is not inevitable. The radically new approach to power generation that we'll need may exist already. Mark Nelson examines an idea that defies received wisdom.**

Today's prodigious consumption of electricity is unsustainable. But owners of tellies, washing machines and dishwashers are not minded to trade these for board games, tubs with hand mangles and washing-up brushes. Big problem? Yes. Inevitable? Not necessarily.

Right now everyone is contemplating the incredibly high cost of replacing traditional power stations with nuclear, windpower or wavepower systems. All of these have practical and environmental drawbacks ranging from minor to severe.

## Radical rethink

Frequently received wisdom is wrong. So-called 'eco bulbs' (CFLs or compact fluorescent lamps) are totally un-ecological, as I explained last month. And there's a growing number of radical scientists who consider today's method of electrical power generation and distribution totally out-of-date.

Today, we generate electricity centrally and distribute it to consumers down long cables. It made perfect sense 50 years ago, but does the method still stack up? Does it make sense in a world starved of fossil fuel resources for generating that power?

Not according to energy analyst Walt Paterson, whose new book, *Keeping The Lights On: Towards Sustainable Electricity*, discusses how to deliver a genuinely sustainable electricity system for the future.

The self-professed troublemaker trained as a nuclear physicist and has spent the rest of his life teaching, writing and acting as a consultant. Now he proposes an entirely different way to think about energy, what we want from it and how we get it.

In his view, we can still enjoy the benefits of having electricity on tap; the only thing is that we'll produce it locally instead of centrally. This will require major investment but if this is the cheapest way of 'keeping the lights on', then it certainly deserves consideration. At the same time it opens the door to vast opportunities for designers and manufacturers to supply the electronic systems for supporting the new paradigm.

## Paterson's patter

According to Walt Paterson, "Traditional electricity is a century old, obsolete and overdue for improvement. But we keep getting it wrong. The decisions that governments and companies are taking now are making matters worse, missing opportunities all over the world."

But although innovative technologies, novel finance models and greener business ethics all simplify the route towards sustainable electricity services, the evolution is much too slow. Too many governments, too many companies, too many people cling stubbornly to out-of-date assumptions and mindsets, argues Paterson.

So what does he advocate? In a nutshell, the decentralisation of power generation. A very substantial amount of the electricity used in homes and offices worldwide is used to keep the ambient temperature more agreeable. Better thermal insulation and ventilation would eliminate much of the energy currently used in poorly designed buildings. Installing this in existing buildings is expensive but would cost far less if designed into all new buildings.

We also waste a lot of power on lights left on unnecessarily; simple time switches linked to motion detectors can switch off unneeded lights in factories and offices. These switches are available now but the cost of buying and retro-fitting them in existing buildings is a serious disincentive. Making them compulsory in new structures would open new mass markets, bringing down unit prices and guaranteeing reduced electricity bills.

## Wrong model

The measures just described would reduce the amount of power used, as would greater use of more efficient (LED-based) light sources. Nevertheless, they are only palliatives and do not address the root cause of our waste of electricity – producing more than we need.

Unlike other public utilities such as water or gas, mains electricity cannot be stored. It has to be generated at the time it is used. The system, explains Paterson, therefore needs to have enough generation capacity available to meet the maximum load on the system. For most of the day, however, this generation operates below its maximum output or else stands idle.

To match the quantity of power generated to people's needs we can do this far more accurately on a small-scale decentralised basis, either locally for small groups of consumers or on-site per building or group of properties. Gas engines are feasible as are microturbines and solid-state inverters supplied by banks of batteries charged by solar cells and wind turbines. Stirling engines and fuel cells will be commercially more attractive too. "But such local generation still faces stubborn opposition in some quarters", remarks Paterson with obvious regret.

## Dreams into reality

Early moves in this direction are already looking promising. A textbook scheme of this kind is working in Woking (Surrey), where the local authority installed the first sustainable community energy system of its type in the world. The technical description is combined heat and power (CHP) co-generation, in which the heat produced in generating electricity is captured to produce hot water and central heating, unlike conventional power stations, which lose heat from electricity generation to the atmosphere.

Phase 1 of Woking's sustainable community energy network serves the Civic Offices, the Victoria Way Car Park (where the CHP station is located), two hotels, a conference and events centre and other premises. Surplus power is exported to other local buildings and sheltered housing. Woking is also the location of the UK's first combined residential photovoltaic/CHP project, where the integrated photovoltaics (solar cell) roof and CHP system have the potential to achieve 100% sustainability in electricity.

Woking is undoubtedly a world leader in sustainable energy use. The town has the UK's most energy-efficient public sector building stock, while the council offers private householders a condensing boiler for the same price as a conventional boiler. Nearly 10 per cent of Britain's solar photovoltaics are installed in Woking.

Further small-scale CHP plants, in which electronics have a vital control function, are being rolled out without fuss or commotion all over the country now. These so-called 'micro CHP' systems are being installed in a growing number of new residential developments by local authorities and housing associations, supplying affordable and constant, low-cost hot water, heating and electricity, and reduces emissions of carbon dioxide.

A typical system is the one supplied by specialist supplier EC Power Ltd at the Abbeyfields sheltered housing scheme in Faversham, Kent, which the company estimates will reduce Swale Housing Association's carbon dioxide output by 12,000kg per year.

## Fantastic prospect?

Is this fantastic news for those worried about the planet – or simply fantasy? It's far too soon to determine but supporters of this approach are putting up powerful arguments. Walt Paterson is under no illusions and the last word goes to him.

"Sustainability can only emerge gradually, in electricity as in every other aspect. Minds, however, can change rapidly. If people stop taking the existing structure of electricity for granted, begin to examine and question it, and come to feel that an alternative structure would be preferable, this change of mind will have a fundamental effect on decisions taken from then on. If decisions are made not by some central authority but by a wide range of participants with varied interests, who see electricity differently, the effect may be untidy but dramatic."


**Is the sound of a V8 music to your ears? Does the roar and deep rumble of a V8 engine raise your pulse rate? With this V8 doorbell you can impress your friends and neighbours. You can have the sound of a V8 without even starting your car. In fact, you don't even need a car.**

Does the sound of a powerful V8 instead of a boring 2-tone doorbell appeal to you? This V8 doorbell really does sound like a V8 and it is loud as well, with an inbuilt 5-watt amplifier.

Not only does it sound like a proper V8, it also lights up an 8-LED 'V' display, each time you press the doorbell pushbutton. In fact, you can have a V8-LED display at your front door and another on the doorbell case.

The V8 Doorbell is housed in a plastic case and is powered by a plugpack. For normal use, the internal 100mm diameter loudspeaker can be used and this provides a good simulation of the V8 sound, particularly if the loudspeaker is 'tuned' using a length of PVC pipe – more on this later. For more volume, you can use a larger loudspeaker or if you want to go the whole hog, connect a bigger power amplifier and loudspeaker.

If the V8 Doorbell does not sound quite how you like it, you can easily tailor the circuit to make small changes to the way the V8 sounds. Altering the software can make even greater changes. That way, you may be able to reproduce the sound of your favorite V8.

We even allow for simulation of V6 engines. Well, grudgingly, and there are some restrictions on the settings that can be used. But enough of puny engines; let's get back to V8s.

## That 'luvverly' V8 burble

V8s have a characteristic sound that makes them stand out from smaller engines. Each marque has its own 'sound' that distinguishes it from the others and much effort is made by the manufacturers to ensure that their V8 has the most appealing 'signature'.

The characteristic V8 sound is mainly determined by the way the exhaust system is configured. In a typical V8, each cylinder of the engine is connected to an exhaust outlet pipe with four pipes merging into one, on each side of the engine.

Some V8s have completely separate left and right exhaust systems (twin exhausts). The lengths of pipe between the engine and silencer affect the way the sound is mixed from the two sides of the engine. In a single exhaust system, one exhaust pipe must be longer than the other, to reach to the one side of the car body. In a twin exhaust, the mixing happens in the air and at our ears.

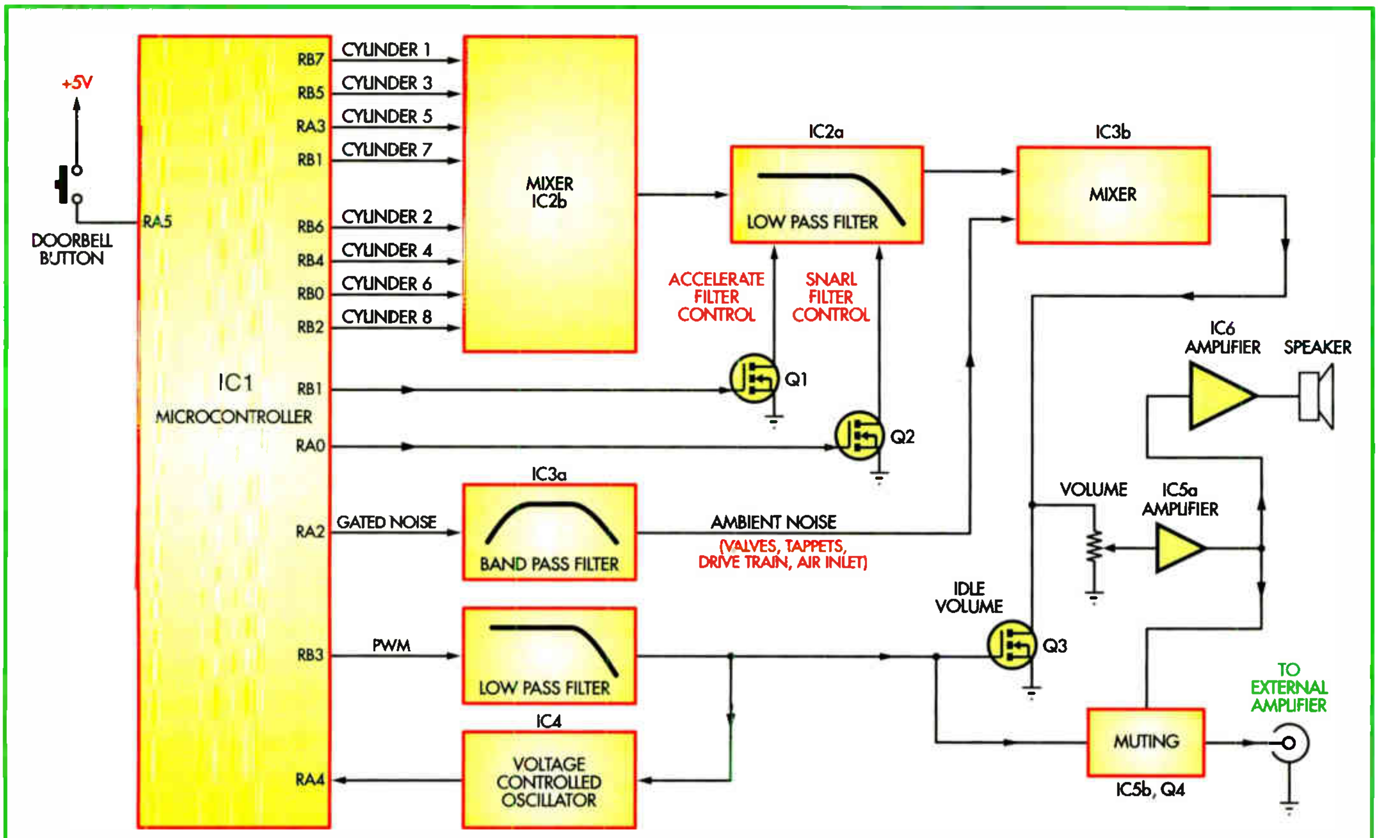



**Fig.1: the block diagram of the V8 Doorbell. Most of the action takes place inside the microcontroller but there's also some fancy filtering and mixing to get the V8 'burble' sound we want.**

## Block diagram

We have simulated the sound of a V8 with the above principles in mind. The block diagram of Fig.1 shows how it is done. When the doorbell is pressed, the microcontroller begins to produce signals from eight ports to simulate the firing of the eight cylinders. They produce tones in a sequence similar to the firing in a real engine. Typically, there can be an overlap between when one cylinder fires and the next, so in effect there can be two sources of signal at any one time.

In this design, you can select several overlap options and the degree of overlap between the cylinders will affect the sound of the simulated engine. The overlaps that can be selected are a 60° overlap, a 30° overlap, zero overlap or a 30° gap between cylinder firing.

Cylinder outputs 1-4 produce their tones with different phasing to that of cylinder outputs 5-8. This is to simulate mixing of the left and right side exhausts of the engine. You can alter the phase from its initial 180° setting to any other value in steps of about 20°.

Cylinder outputs are mixed together in IC2b and then fed through a low-pass filter. This filter acts like a silencer in that it attenuates high frequency noise but allows through some low frequency noise. The Accelerate Filter Control (Q1) and the Snarl Filter Control (Q2) alter the way the filter works. These make changes to the filter characteristics to allow more high frequency signals to pass during acceleration and at high RPM simulation.

The microcontroller's RA2 port functions as a gated noise source, generating random noise only during part of each cylinder's firing cycle. This simulates valve, tappet, drive train and air inlet sounds. This is fed to bandpass filter IC3a and then mixed with the cylinder signal by IC3b.

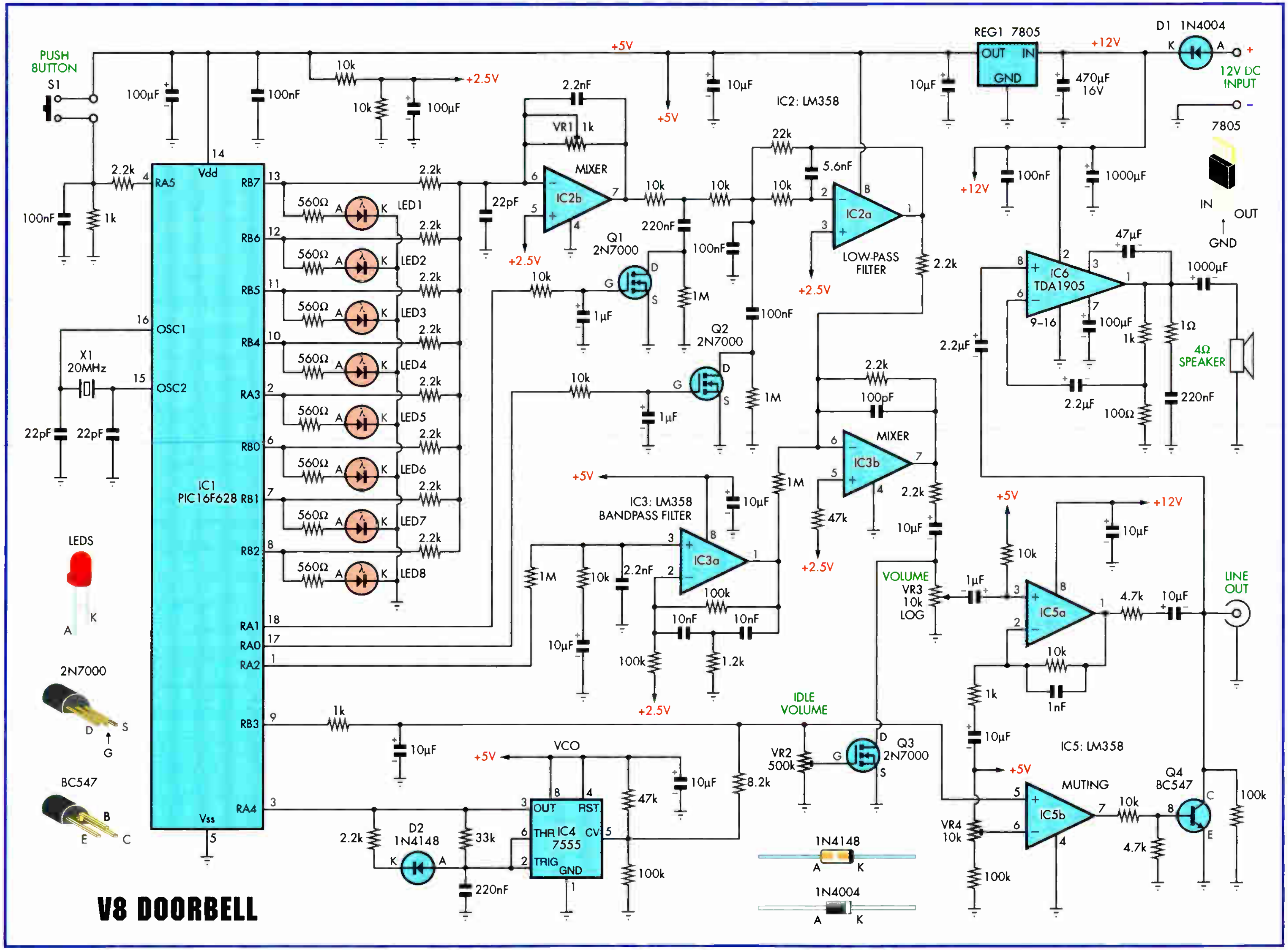
Transistor Q3 provides for an increase in volume level at higher RPM, under control of a pulse width modulated (PWM) signal from port RB3 of the micro. After filtering, the PWM signal becomes a DC voltage to drive Q3. This DC voltage also controls a voltage controlled oscillator (VCO) which alters its frequency depending on the input voltage. The VCO's output is fed to port RA4 of IC1 and it therefore determines the effective engine RPM.

The final signal is fed to the volume control pot and amplifier IC5a. This is muted so that there is no signal until the doorbell is pressed. Power amplifier IC6 drives the loudspeaker.

## Circuit details

Fig.2 shows the complete circuit. IC1 is a PIC16F628 microcontroller that produces the simulated V8 engine signals. IC1 operates at 20MHz, as set by crystal X1.

The doorbell input at RA5 is normally low (0V) when switch S1 is open, since the 1kΩ resistor pulls it to ground. When the switch is closed, the input is pulled to +5V. A 100nF capacitor across the resistor removes noise picked up by the doorbell wiring, while the 2.2kΩ resistor acts to restrict current to the RA5 input if there is a transient voltage spike. The closed switch is detected by IC1 and so it begins to produce the engine sound sequence.


PUSH BUTTON
S1
100µF
100nF
10k
+2.5V
100µF
+5V
2.2nF
VR1 1k
MIXER
IC2b
22pF
+2.5V
10µF
IC2: LM358
22k
5.6nF
IC2a
LOW-PASS FILTER
2.2k
+2.5V
REG1 7805
OUT IN
GND
+12V
470µF 16V
D1 1N4004
12V DC INPUT
7805
IN OUT GND
100nF
1000µF
+12V
47µF
IC6 TDA1905
1000µF
100µF
1k
1Ω
4Ω SPEAKER
2.2µF
100Ω
220nF
9–16
2.2k
Q1 2N7000
220nF
100nF
1M
1µF
Q2 2N7000
100nF
2.2k
100pF
MIXER
IC3b
1M
47k
+2.5V
10µF
IC1 PIC16F628
Vdd
RA5
RB7
RB6
RB5
RB4
RA3
RB0
RB1
RB2
RA1
RA0
RA2
RB3
RA4
Vss
OSC1
OSC2
X1 20MHz
22pF
560Ω
LED1
LED2
LED3
LED4
LED5
LED6
LED7
LED8
LEDS
2N7000
BC547
+5V
IC3: LM358 BANDPASS FILTER
IC3a
2.2nF
100k
10nF
1.2k
+2.5V
VOLUME VR3 10k LOG
1µF
IC5a
4.7k
LINE OUT
1nF
IDLE VOLUME
VR2 500k
Q3 2N7000
8.2k
VCO
IC4 7555
OUT RST
THR CV
TRIG GND
33k
D2 1N4148
220nF
IC5: LM358
MUTING
IC5b
VR4 10k
Q4 BC547
1N4148
1N4004

V8 DOORBELL

**Fig.2 (left): the complete circuit of the V8 Doorbell. A PIC16F628 microcontroller (IC1) produces the simulated V8 engine signals. These signals are then processed and fed to audio amplifier stage IC6.**

The port outputs at RB0 to RB2, RA3 and RB4 to RB7 are applied via 2.2kΩ resistors to op amp IC2b, connected as a mixer with its gain set by trimpot VR1. These ports also drive LEDs 1 to 8 via 560Ω resistors to give the V8 display. Op amp IC2a is the low-pass filter stage. In its normal state, this filter acts to sharply roll off the signal above 600Hz when MOSFETS Q1 and Q2 are both switched on.

When Q1 is switched off, its associated 220nF capacitor is effectively switched out of circuit and this reduces the filter's effectiveness at rolling off signal levels above 185Hz. Similarly, when Q2 is switched off, the 100nF capacitor is out of circuit and the filter action is further reduced.

The 1MΩ resistors tying the capacitors to ground are included to maintain the DC voltage across these capacitors so that there is no DC shift in signal when they are switched in or out. Q1 and Q2 are controlled by the RA1 and RA0 outputs of IC1 respectively. The 10kΩ resistor and 1µF capacitor on the gate (G) of each MOSFET slow down the switch-on and switch-off rates of the MOSFETS to eliminate switching noise.

In practice, both MOSFETS are switched on during idle to provide the full effect of the filter. When the 'engine' speed is increased, Q1 is switched off to produce the noise of acceleration and as RPM rises further, Q2 is switched off for the 'snarl' effect at high RPM. The low-pass filter output at pin 1 of IC2a is fed to op amp IC3b, another mixer, via a 2.2kΩ resistor.

## Parts List – V8 Doorbell

1 main PC board, code 637, available from the *EPE PCB Service*, size 171mm × 105mm
1 display PC board, code 638, size 56 x 48mm
1 plastic utility box, 197 x 113 x 63mm
1 12V DC 1A plugpack
1 4Ω 100mm diameter loudspeaker
1 130mm length of 100mm diameter PVC tubing
1 doorbell switch (S1)
1 20MHz crystal (X1)
1 8-way right-angle pin header
1 8-way pin header
2 8-way pin header sockets
1 2-way PC-mount screw terminal block
1 2.5mm DC socket
1 panel-mount RCA phono socket
1 knob to suit potentiometer
1 80mm length of 8-way rainbow cable
1 150mm length of 3-way rainbow cable
1 80mm length of hookup wire
1 80mm length of single-core shielded cable
1 80mm length of figure-8 light duty wire
1 suitable length of figure-8 doorbell wire
1 150mm length of 0.8mm tinned copper wire
4 12mm M3 tapped spacers
13 M3 x 10mm screws
5 M3 nuts
9 PC stakes

**Semiconductors**
1 PIC16F628 microcontroller programmed with engine3.hex (IC1). Ready-programmed PICs are available from Magenta Electronics – see their advert
3 LM358 dual op amps (IC2, IC3, IC5)
1 7555 CMOS timer (IC4)
1 TDA1905 5W amplifier (IC6)
3 2N7000 MOSFETS (Q1-Q3)
1 BC547 NPN transistor (Q4)
1 7805 5V regulator (REG1)
1 1N4004 1A diode (D1)
1 1N4148 switching diode (D2)
8 5mm red high intensity LEDs (LED1-LED8)

**Capacitors**
2 1000µF 16V PC electrolytic
1 470µF 16V PC electrolytic
3 100µF 16V PC electrolytic
1 47µF 16V PC electrolytic
10 10µF 16V PC electrolytic
2 2.2µF 16V PC electrolytic
3 1µF 16V PC electrolytic
3 220nF MKT polyester
5 100nF MKT polyester
2 10nF MKT polyester
1 5.6nF MKT polyester
2 2.2nF MKT polyester
1 1nF MKT polyester
1 100pF ceramic
3 22pF ceramic

**Resistors (0.25W 1%)**

| | |
|---|---|
| 4 1MΩ | 2 4.7kΩ |
| 5 100kΩ | 13 2.2kΩ |
| 2 47kΩ | 1 1.2kΩ |
| 1 33kΩ | 5 1kΩ |
| 1 22kΩ | 8 560Ω |
| 11 10kΩ | 1 100Ω |
| 1 8.2kΩ | 1 1Ω |

**Potentiometers**
1 1kΩ multi-turn side adjust screw trimpot (code 102) (VR1)
1 500kΩ horizontal trimpot (code 504) (VR2)
1 10kΩ log 16mm potentiometer (VR3)
1 10kΩ horizontal trimpot (code 103) (VR4)

## Gated noise

Gated noise from the RA2 output of IC1 is attenuated via a voltage divider comprising a 1MΩ resistor and a 10kΩ resistor in series with a 10µF capacitor. The 10nF capacitors and 1.2kΩ resistor form a half-T filter that allows a relatively narrow band of frequencies, centred on about 6.6kHz, to pass through. The 100kΩ resistor between pin 2 and pin 1 broadens the bandwidth of the filter to allow a wider range of frequencies to pass than if the resistor was not present. The output of IC3a is fed to mixer IC3b via a 1MΩ resistor.

The output from IC3b is passed through a 2.2kΩ resistor and a 10µF DC blocking capacitor. MOSFET Q3 shunts this signal to ground when conducting but has no effect on the signal throughput when it is switched off.

Q3 is controlled via the filtered PWM signal from pin 9 of IC1. The 1kΩ resistor and 10µF capacitor filter this 19kHz signal and the filtered DC voltage is applied via trimpot VR2 to the gate of Q3.

Op amp IC5a is a non-inverting amplifier with a gain of 11. It amplifies the signal taken from the wiper of VR3 so that the level is suitable for the following power amplifier. IC5a is biased at +5V so that when there is no signal, its pin 1 output sits at 5V. This allows a large voltage swing before the output clips. High

**Table 1: Capacitor Codes**

| Value | µF Code | IEC Code | EIA Code |
|---|---|---|---|
| 220nF | 0.22µF | 220n | 224 |
| 100nF | 0.1µF | 100n | 104 |
| 10nF | 0.01µF | 10n | 103 |
| 5.6nF | 0.0056µF | 5n6 | 563 |
| 2.2nF | 0.0022µF | 2n2 | 222 |
| 1nF | 0.001µF | 1n0 | 102 |
| 100pF | NA | 100p | 100 |
| 22pF | NA | 22p | 22 |

frequency roll-off for the amplifier is set at around 16kHz to prevent high-frequency instability. Its output is coupled to power amplifier IC6 via a 4.7kΩ resistor and a 10µF DC blocking capacitor.

Transistor Q4 provides muting of the output signal and is controlled by comparator IC5b and the filtered PWM signal from pin 9 of IC1. IC5b operates in the following way. When the circuit is quiescent (ie, not producing any V8 sounds), the filtered PWM signal is at 5V. This is monitored at pin 5 of IC5b and is compared with the voltage set by trimpot VR4, fed to pin 6. VR4 is set so that pin 6 is at about 4.7V and so pin 7 of IC5b will be high at around 11V. This high signal drives the base of Q4 which therefore shunts any noise signals to ground.

When the doorbell is pressed, the microcontroller begins to produce the V8 sounds and the PWM signal immediately drops to 4.5V and so pin 7 of IC5b goes low and Q4 is switched off. The signal at IC5a's output now passes to the Line output socket and to IC6, the power amplifier.

## Power amplifier

IC6 is a TDA1905 power amplifier rated to produce 5W into 4Ω with a 14V supply. It includes thermal shutdown if it overheats and a very low noise output. For the intermittent use it gets in this circuit, it is ideal. Gain of the amplifier is set at 11 by the 100Ω and 1kΩ resistors connected between pin 1 and ground, with the feedback signal AC-coupled to pin 6 via a 2.2µF capacitor.

The 100µF capacitor at pin 7 provides supply ripple rejection, while the 47µF capacitor between pin 1 and pin 3 provides classic bootstrapping between the amplifier's output and driver stages. A 1000µF capacitor across the 12V supply provides a reserve for transient power output while a 100nF bypass capacitor provides high-frequency filtering.

IC4 is a CMOS 555 timer set up as a voltage controlled oscillator (VCO). Its output is fed to port RA4 (pin 3) of the microcontroller to determine the audible engine RPM.

Pin 5 (threshold control) is used to set the output frequency. When pin 3 of IC4 is low, diode D2 discharges the 220nF capacitor at pins 2 and 6 relatively quickly, via the series connected 2.2kΩ resistor. When pin 3 goes high, the 220nF capacitor only charges via the 33kΩ resistor since D2 is now reversed-biased.

The resulting pulse waveform at pin 3 has a relatively short low period and a longer high-level period; ie, a high duty cycle. We then vary the voltage at pin 5 to control the output frequency. When pin 5 is up around 5V, the frequency is low and if pin 5 is low the frequency is higher.

Power for the circuit is provided by a 12V DC plugpack. Diode D1 prevents damage if the supply is connected the wrong way round, while the 470µF capacitor provides extra filtering. The 12V supply feeds IC5 and IC6 while REG1, an LM7805 5V regulator, supplies the rest of the circuit.

## Construction

The V8 Doorbell is built onto two PC boards: a main board coded 637 (171 x 105mm) and an LED display board coded 638 (56 x 48mm). The two PC boards and the 100mm diameter loudspeaker are housed inside a plastic utility box measuring 197 x 113 x 63mm.

Before installing any of the parts, check the two PC boards for any shorts between the copper tracks or for any breaks in the connections. Also check the hole sizes. You will need 3mm holes for the mounting positions in the four corners of the display PC board and for the regulator screw on the main PC board.

That done, begin the assembly by installing the links and resistors on the main PC board – see Fig.3. Use the resistor colour table as a guide to selecting each resistor, then check each value using a digital multimeter.

Once the resistors are in, the diodes can be installed, taking care with their orientation. Follow these with IC2 to IC6, make sure that each IC goes in the correct position and is mounted the right way around.

An IC socket must be used for IC1, the PIC. Install it now, then solder in the three MOSFETS (Q1 to Q3) and transistor Q4.

**Table 2: Resistor Colour Codes**

| ❑ | No. | Value | 4-Band Code (1%) | 5-Band Code (1%) |
|---|---|---|---|---|
| ❑ | 4 | 1MΩ | brown black green brown | brown black black yellow brown |
| ❑ | 5 | 100kΩ | brown black yellow brown | brown black black orange brown |
| ❑ | 2 | 47kΩ | yellow violet orange brown | yellow violet black red brown |
| ❑ | 1 | 33kΩ | orange orange orange brown | orange orange black red brown |
| ❑ | 1 | 22kΩ | red red orange brown | red red black red brown |
| ❑ | 11 | 10kΩ | brown black orange brown | brown black black red brown |
| ❑ | 1 | 8.2kΩ | grey red red brown | grey red black brown brown |
| ❑ | 2 | 4.7kΩ | yellow violet red brown | yellow violet black brown brown |
| ❑ | 13 | 2.2kΩ | red red red brown | red red black brown brown |
| ❑ | 1 | 1.2kΩ | brown red red brown | brown red black brown brown |
| ❑ | 5 | 1kΩ | brown black red brown | brown black black brown brown |
| ❑ | 8 | 560Ω | green blue brown brown | green blue black black brown |
| ❑ | 1 | 100Ω | brown black brown brown | brown black black black brown |
| ❑ | 1 | 1Ω | brown black gold gold | brown black black silver brown |

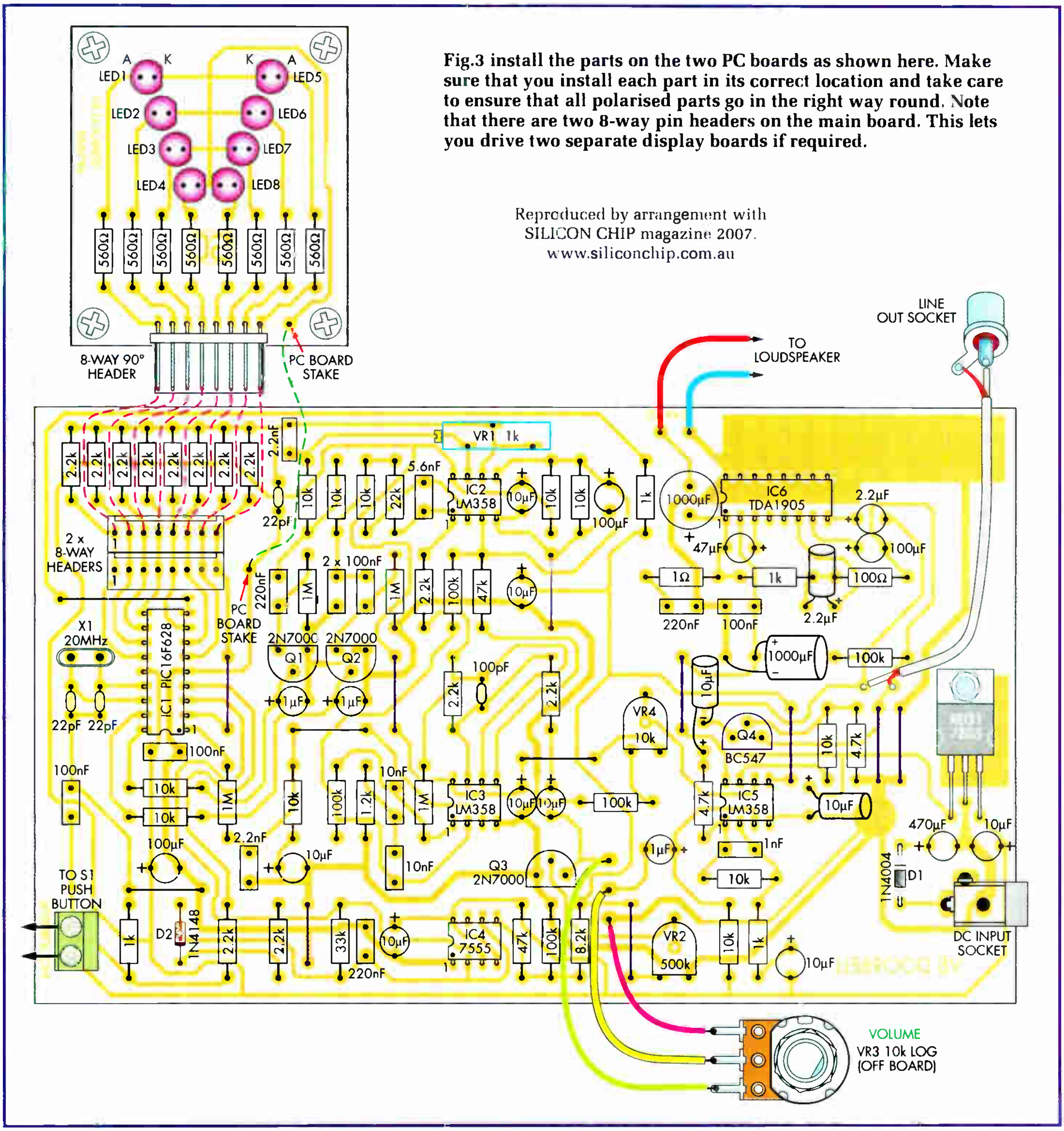



**Fig.3 install the parts on the two PC boards as shown here. Make sure that you install each part in its correct location and take care to ensure that all polarised parts go in the right way round. Note that there are two 8-way pin headers on the main board. This lets you drive two separate display boards if required.**



The trimpots and capacitors can go in next. When installing the capacitors, note that the polarised types must be installed with the correct polarity. Note also that three electrolytic capacitors have to be placed on their side, so that there is room for the loudspeaker later on (see layout diagram photos).

Regulator REG1 is mounted with its metal tab flat against the PC board. This involves first bending its leads at right-angles so that they pass through their matching holes in the board. That done, the regulator tab is secured to the board using an M3 screw and nut and the leads soldered.

The following parts can now all be installed: the 2-way terminal block, the DC socket, the eight PC stakes (at the external wiring points shown) and the 2 × 8-way pin headers (the right-angle header is installed on the display PC board).

You will need to connect the two header socket shells using 8-way rainbow cable. This is done by stripping the wire ends and crimping them to the pins supplied. These pins are then slid into the header shells.

## Display board assembly

The display PC board can now be assembled. For the time being, it's just a matter of installing the resistors, the

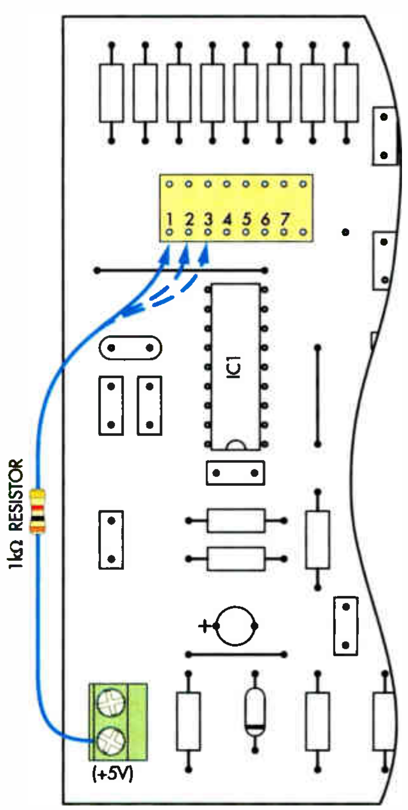



**Fig.4: you can change the sound produced by your V8 Doorbell by making the connections shown here and then applying power – see text for further details.**

right-angle header plug and a PC stake. Don't install the LEDs just yet – that step comes later.

Putting aside the display board for the moment, our next task is to prepare the case. This involves drilling eight holes in a 'V' pattern for the eight LEDs, plus four mounting holes each for the display board and the loudspeaker. In addition, you will also have to drill holes in the lid in front of the loudspeaker cone area, to allow sound to escape.

Another hole is required in the front panel for the volume control pot. And finally, two holes are required in one end of the base for the RCA (phono) output socket and the DC power plug, plus another hole in the opposite end for the doorbell switch wire entry.

The four 12mm tapped Nylon spacers can now be fastened to the lid at the display board mounting points. These are secured using four M3 × 6mm screws.

That done, slip the eight LEDs into their mounting holes on the PC board (make sure you get them the right way around), then secure the board to its spacers. It's then simply a matter of pushing the LEDs through their respective holes in the front panel and then soldering their leads to their copper pads.

Finally, the loudspeaker and pot can be secured to the lid and the wiring completed as shown in Fig.3. Don't forget to run the wire lead from the PC stake near the 8-way header on the main board to the PC stake on the display board.

## Test and adjustment

Now for the smoke test. First, apply power to the circuit and check for 5V between pins 4 and 8 of both IC2 and IC3, between pins 1 and 4 of IC4 and between pins 5 and 14 of IC1. That done, check for about 12V between pins 4 and 8 of IC5 and pins 2 and 9 of IC6.

If these voltages are correct, switch off and install IC1 in its socket. However, if there are no voltages, check the polarity of the DC plug on the plugpack. The centre pin should be positive.

OK, now let's see if it actually works. To do this, connect the doorbell switch to the terminal block (using figure-8 wire) and adjust the various trimpots as follows:

(1) set VR1 fully anticlockwise;
(2) set VR2 and VR3 fully clockwise;
(3) set VR4 so that its wiper voltage is at +4.7V with respect to ground.

Now press the doorbell and slowly adjust multi-turn trimpot VR1 clockwise. The engine sound should start to increase in volume. The final setting for VR1 depends on personal preference – set it too far clockwise and the sound will become very harsh. A lower setting will produce a cleaner engine sound.

Trimpot VR2 is set so that you obtain the required idle volume, compared to the 'rev up' volume. It's just a matter of slowly adjusting this pot until the idle volume is suitably lower than the 'revved-up' volume.

If required (ie, if you want more 'ooomph'), a 100mm PVC pipe joiner (or 120mm length of pipe) can be secured to the lid in front of the loudspeaker using silicone sealant. This 'tuned' pipe makes the sound more resonant and penetrating. If you like, you can try different lengths of pipe to vary the effect.

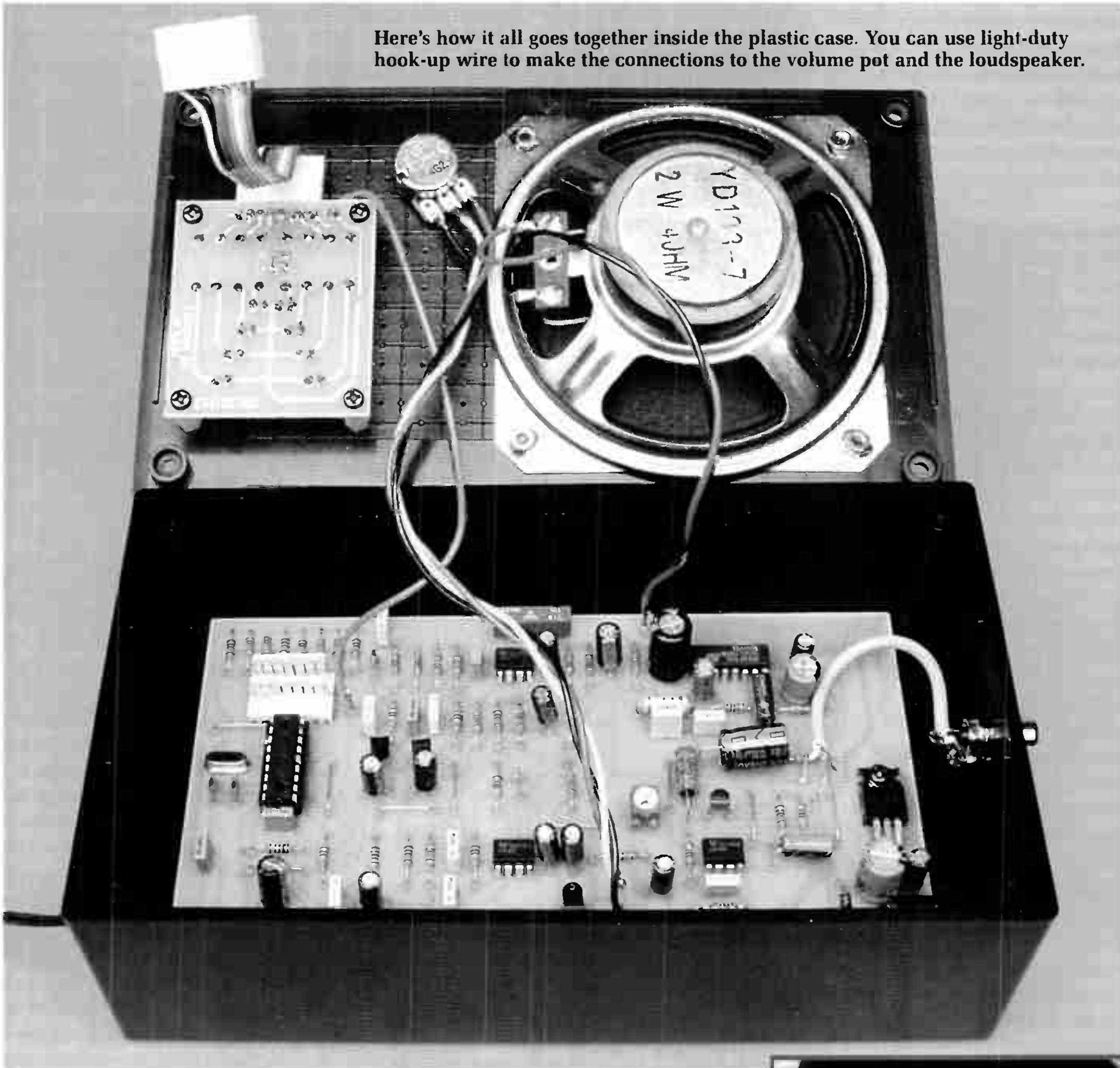
Note that you may need to file some slots in the pipe so that it clears the loudspeaker mounting screws.

## Individual preferences

There are seven setting changes that can be made to IC1's software to produce different sounds. This involves connecting a wire and a series 1kΩ resistor between the +5V terminal (for the doorbell switch) and one of seven terminals on the 8-way header pin, as shown in Fig.4.

When a connection is made to one of these pins during power up, the required software change is made automatically. Note, however, that it's important that the +5V supply rail is fully discharged to 0V before powering up if the change is to take effect.


**The unit gives a good V8 sound on its own but it's even better with the tuned pipe installed.**




Here's how it all goes together inside the plastic case. You can use light-duty hook-up wire to make the connections to the volume pot and the loudspeaker.

In fact, it's a good idea to measure the voltage between the +5V terminal of REG1 and ground after the power is switched off, to ensure the power has been completely removed.

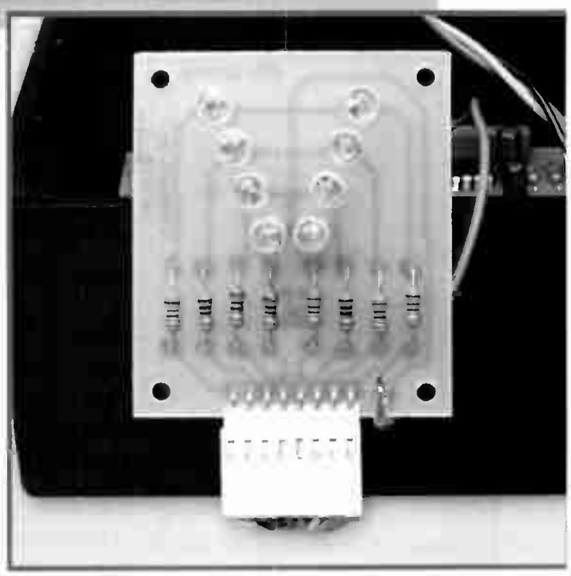
Note also that the resistor only has to be connected at power up. It can then be disconnected when you are satisfied with the new sound. The options available are summarised below:

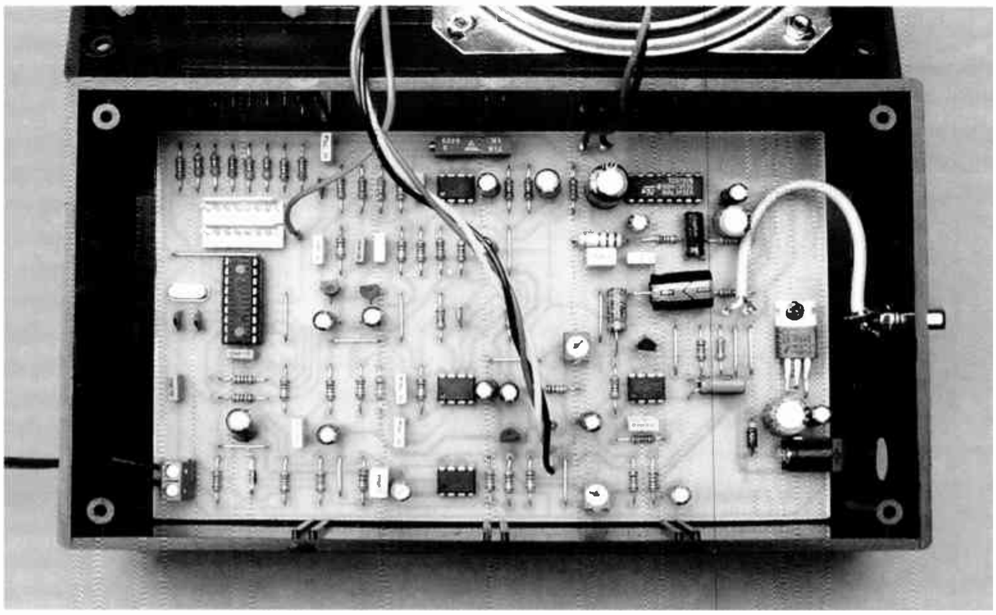
**Terminal 1:** you can adjust the V8 sound to simulate different lengths of exhaust pipe between the lefthand and righthand sides of the engine. This is the phasing adjustment. Phasing can be altered in steps of about 20°, from its original default of 180°.

**Terminal 2:** the 180° default setting of the phase and the exhaust note frequency can be reset using this input (see Terminals 5 and 6 below).

**Terminal 3:** this terminal alters the amount of overlap for the sound generated by each cylinder firing. It can be altered in sequence from 60° to 30° to 0° and finally to a 30° gap.

**Terminal 4:** the 6 or 8-cylinder selection is made using this input. This alternatively selects either setting, with the LED display showing which cylinders are firing.





The PC board is secured by clipping it into the integral slots in the side of the case. Power comes from a 12V DC 1A plugpack.

Note that only the 0° and 30° gap settings should be used in 6-cylinder mode. Do not use the 60° and 30° overlap settings, as this will simulate a 6-cylinder engine with an erratic seventh cylinder. The correct setting will be seen on the 'V' display when only six LEDs light. If seven LEDs light, change the overlap setting using Terminal 3.

**Terminals 5 and 6:** these inputs allow the exhaust frequency to be altered slightly. Terminal 5 increases the frequency, while Terminal 6 lowers it.

If the frequency is increased too far from the original value, the sound will have a 'raspy' quality at the top of the rev range. However, it takes many applications of power to make large changes to the frequency.

The frequency can be reset to its default value using Terminal 2.

**Terminal 7:** this selects whether the doorbell includes an idling period before the two revving sequences.

## Other changes

The idle RPM can be set by changing the 33kΩ resistor at pin 3 of IC4 – a larger resistance will lower the RPM or you can use a 50kΩ trimpot to adjust this to your liking.

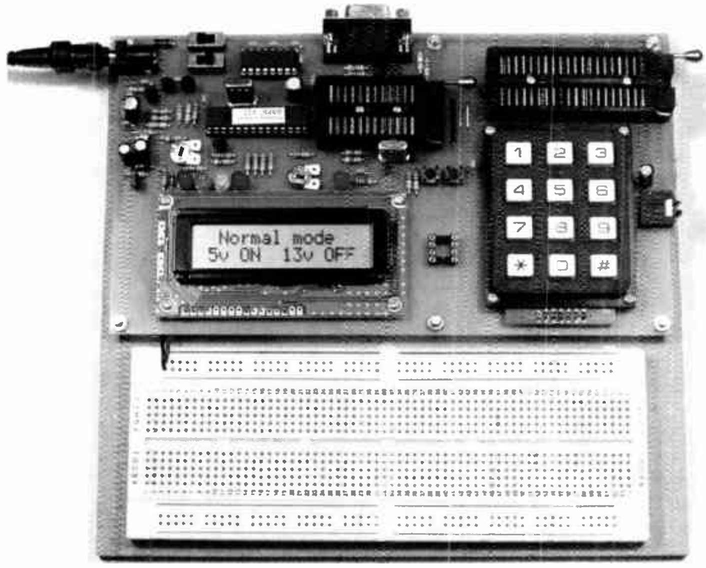
The ambient noise can be increased in frequency by decreasing the 1.2kΩ resistor in the 'twin-T' filter of IC3a and vice versa. In addition, the 10kΩ resistor at pin 3 of IC3a sets the degree of mixing with the cylinder firing sound. A lower value will reduce the ambience and vice versa, or you can use a 22kΩ trimpot to adjust this.

You can also make major changes to the doorbell sound characteristics by altering the software. To do this, you will need to be able to modify the software, reassemble the code and re-program IC1. Some PIC programming experience will be necessary.

A much fuller sound is available if you use a large loudspeaker housed in a suitable box. For more volume, you may want to use a more powerful amplifier and this can be connected using the RCA phono line output socket.

If you do this, you can either disconnect the internal loudspeaker or you can leave it connected so that it operates as an extension. *EPE*

# Learn About Microcontrollers




## PIC Training Course £159

The best place to begin learning about microcontrollers is the PIC16F627A. This is very simple to use, costs just £1.30, yet is packed full of features including 16 input/output lines, internal oscillator, comparator, serial port, and with two software changes is a drop in replacement for the PIC16F84.

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and PIC18F2321 test PICs. . . . . . . . . . . £159.00
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## Experimenting with PIC Microcontrollers

This book introduces PIC programming by jumping straight in with four easy experiments. The first is explained over ten and a half pages assuming no starting knowledge of PICs. Then having gained some experience we study the basic principles of PIC programming, learn about the 8 bit timer, how to drive the liquid crystal display, create a real time clock, experiment with the watchdog timer, sleep mode, beeps and music, including a rendition of Beethoven's *Fur Elise*. Then there are two projects to work through, using a PIC as a sinewave generator, and monitoring the power taken by domestic appliances. Then we adapt the experiments to use the PIC16F877 family, PIC16F84 and PIC18F2321. In the space of 24 experiments, two projects and 56 exercises we work through from absolute beginner to experienced engineer level using the most up to date PICs.

## Experimenting with PIC C

The second book starts with an easy to understand explanation of how to write simple PIC programmes in C. Then we begin with four easy experiments to learn about loops. We use the 8/16 bit timers, write text and variables to the LCD, use the keypad, produce a siren sound, a freezer thaw warning device, measure temperatures, drive white LEDs, control motors, switch mains voltages, and experiment with serial communication.

**Web site:- www.brunningsoftware.co.uk**

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Visual C# Training Course comprising.....

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+ AUX200 latching serial port
+ liquid crystal display assembly
+ programme text on CD
+ pack of components. . . . . . £88.00
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You will need to download Visual C# Express which is free. Full instructions are in the book.

In October 2003 Martin Crane purchased our original PIC training course and in September 2005 he updated to the latest version. Three weeks before Christmas 2006 we had a telephone call from Mrs Crane to order our Visual C# training course as a Christmas present for her husband. On 21st March 2007 we received an email from Martin Crane which includes his personal review of the course. Here are a few lines from his text......

For years I've wished to write my own applications that control external equipment from my PC.

**Eureka!!** Peter Brunning has shown just how simple it really is. I am up and running at last. Most people seem to start with Visual BASIC, I found it truly frustrating. C# has combined everything you could wish for and more besides. The visual interface will be instantly familiar to Visual BASIC users but with far more options. The code side is dealt with by Peter in such a way that with no knowledge what so ever you can within a very short time be using the serial port. Brunning Software's serial port interface (included with the course) comes preprogrammed but the code is listed in the book together with the available features. Congratulations Peter for producing a truly hands on training package.

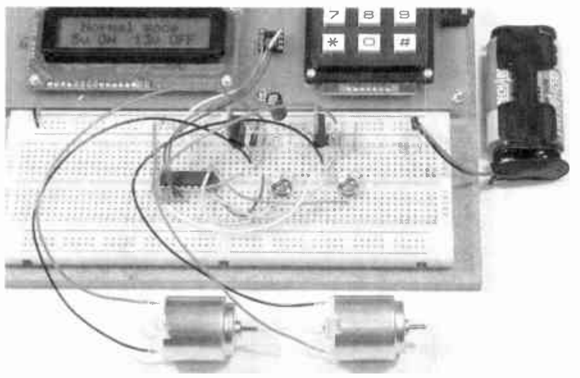
Martin Crane
(a very satisfied customer)

See:- www.brunningsoftware.co.uk/vcreview.htm

## Ordering Information

Both training courses need either a free serial port on your PC or a USB to COM adapter (full details on website). All software referred to in this advertisement will operate within Windows XP, NT, 2000 or later.

Telephone with Visa, Mastercard or Switch, or send cheque/PO. All prices include VAT if applicable.



## White LED and Motors

Our PIC training system uses a very practical approach. Towards the end of the second book circuits need to be built on the plugboard. The 5 volt supply which is already wired to the plugboard has a current limit setting which ensures that even the most severe wiring errors will not be a fire hazard and are very unlikely to damage PICs or other ICs.

We use a PIC16F627A as a freezer thaw monitor, as a step up switching regulator to drive 3 ultra bright white LEDs, and to control the speed of a DC motor with maximum torque still available. A kit of parts can be purchased (£30) to build the circuits using the white LEDs and the two motors. See our web site for details.

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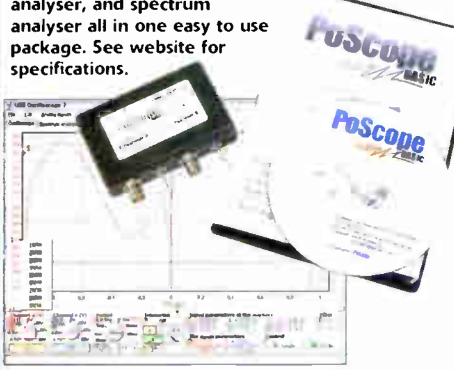


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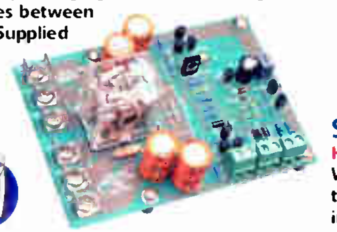

NEW

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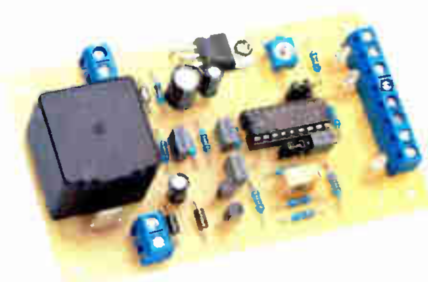
NEW



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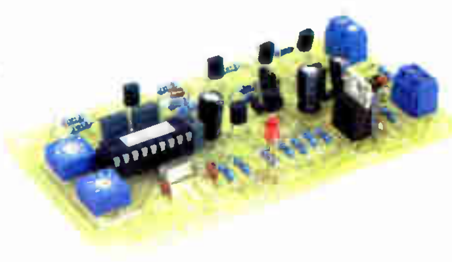

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# PIC N' MIX

MIKE HIBBETT

Our periodic column for your PIC programming enlightenment

## More on 1-wire protocol – and a response to the Brain Teaser challenge!

WE continue on from last month's article on the 1-wire protocol by developing some software routines that can be used to communicate with 1-wire devices. These routines will be written in assembler since this is the language that most *EPE* readers seem to be familiar with, and can be used with applications written either in assembler or a high level language like 'C'.

We will be using MPLAB as the development environment and prototyping the code on the PicKit2 hardware platform, since this ties in nicely with recent tutorial articles. Athough the code is targeted to a PIC16 family part (the PIC16F917) it can be easily 'ported' to other devices in the Microchip range.

### Portable code

Presenting general purpose re-useable assembly language routines is always a difficult task. The author's favorite PIC devices are in the PIC18F range which have additional instructions that can make the code more efficient, but consequently much harder to translate back to a simpler processor family, such as the PIC10F or PIC16F. By choosing a mid-range device, like the PIC16F917, and keeping the code as non-processor specific as possible makes (hopefully!) the porting exercise to other devices as simple as possible.

Do bear in mind that incorporating assembly routines into your code is not the only way to build a 1-wire application; as we mentioned last month, some software vendors provide routines implemented as part of a BASIC language programming environment. You would have to pay for those of course, but if you want to understand how to write the routines yourself (or understand how they were written), there is no real substitute for going right back to basics and walking through the development of the routines. Hopefully, you will gather some understanding of the low level software this month, and will gain the confidence to incorporate the routines in to your own future programs, or even better, modify them for your own special needs.

### Protocol detail

Before we start writing any code, let's take a look at the protocol in more detail. The application note 132 from Dallas/Maxim (available on their website, see reference 1) details this, but in a quite complex manner. We have simplified the timing diagrams to the bare essentials, as shown in Fig.1. It's still complicated, so let's go through them in detail.

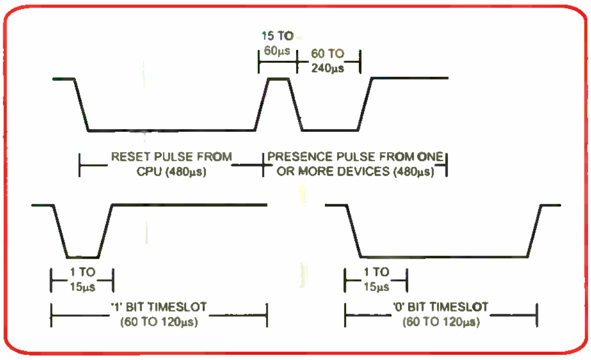


*Fig.1. Basics timings*

The three diagrams in Fig.1 show how the three main activities on the 1-wire data wire are performed. Each diagram shows how the voltage on the data wire varies over time, starting from the left and moving to the right. When the line on the diagram is 'high', it indicates the data wire is at the high voltage: 5V for example. When the line is 'low', it indicates the wire is being driven to zero volts.

The sloping line indicates when the signal is transitioning from one level to another. This transition is normally shown with an exaggerated slope, and in most 1-wire systems the transition can take a few microseconds. Note that the default, idle state of the line is floating, driven 'high' by the bus pull-up resistor.

The first activity used when one wishes to send messages on the bus is the Reset/Presence cycle, shown at the top of Fig.1. This is used at the beginning of any communication with a 1-wire device, as it causes all devices on the bus to reset themselves back to a known default condition.

The procedure is as follows:

1. The CPU drives the wire low for 480µs (this is the 'reset' signal)

2. The CPU then turns its I/O pin to an input, allowing the signal to be pulled high

3. After 15µs, the CPU monitors its input I/O pin to look for a device on the bus driving the wire low (this is the 'presence' signal)

4. 15µs after detecting the reset signal, any device connected to the bus will drive the wire low for at least 60µs to indicate its presence

All devices connected to the bus will drive the signal low, so detecting that the wire has gone low only indicates that there is at least one device on the bus – there could, of course, be hundreds. How you communicate with a specific device is determined by the high level commands mentioned last month.

Once the CPU has finished waiting for the devices to indicate their presence (after a period of about 480µs), the CPU can send out one of the 1-wire messages on the bus. As with any serial communication protocol, messages are sent by 'waggling' a data line up and down, with a 'high' level on the data wire indicating a '1' bit, and a 'low' level on the wire indicating a '0' bit.

With only a single wire available to send the data, some method is required to allow the receiver to 'know' when to look at the data wire for each data bit sent by the transmitter. This is done by sending a short 'low' pulse on the data line prior to sending the actual data bit.

The bottom two diagrams in Fig.1 show how a '1' and a '0' data bit will be sent. By using a short 'trigger' pulse at the start of each data bit, the two devices – the main CPU and the remote 1-wire device – do not need to run tightly aligned clocks to keep in sync.

For the CPU to receive data from a 1-wire device, it simply leaves the I/O pin connected to the data wire as an input and 'listens' for the voltage level to drop to zero volts. The 1-wire protocol describes when a device should transmit and when it should listen, and as all devices connected to the bus will obey the protocol, communication is possible even though there may be hundreds of devices on a single wire.

### Bottom up approach

Writing software for interfaces such as this typically follows a 'bottom up' approach – you start off by thinking about how you will control the voltages on the wire, write and test those, then think about how you will use those routines to generate the correct timing (to correspond with the timing diagrams such as in Fig.1) to give data transfer between devices. Once those routines are written, you can then forget about the hardware issues, put your multimeter away and concentrate on writing software to use the 1-wire protocol commands and messages.

In engineering circles, the low level routines used to provide the transfer of messages over the hardware are called *drivers*. These typically consist of subroutines to initialise the interface, read messages and write messages, and tend to have names like **initHw**, **readByte** and **writeByte**. We will present some suitable driver code in this article, with an example of how to use it.

Developing code to talk to external devices requires the use of a hardware emulator or real hardware – you cannot use a PC simulator such as the one available in the MPLAB IDE. Emulators (complex pieces of hardware that are essentially versions of the PIC processor, with access to some of the internal signals) are expensive, but for an interface like this we can build a very simple circuit on which to test our code.

Of course, if you have a hardware debugger such as the PicKit2 or ICD then testing is even easier. The test circuit shown in Fig.2 uses the PIC16F917, to match the processor on the PicKit2, but you should be able to use any PIC processor with no or minimal changes.

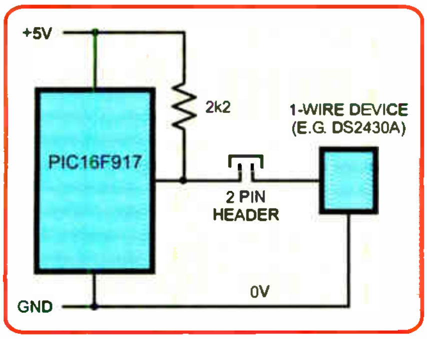


*Fig.2. Debugging test circuit*

The circuit does not show an oscillator – this is because in our example code we will use the internal, calibrated RC oscillator that runs at 8MHz. It makes for a really simple, compact circuit! You can, of course, use an external oscillator if you wish, just change the CONFIG register settings for the clock source appropriately.

With such a simple interface – it can't get any simpler – the choice of which I/O pin to use is easy. Any. We wired a Dallas DS2430A 256-bit EEPROM to the prototyping area on the PicKit2 demo board and used the debugger to assist with the code development, but as this article is about 1-wire interfaces we will ignore the debugging activities.

## Software

Once again, before even thinking about writing your code, think about how you are going to organise it into various source files. Obviously, you will want a file to hold the actual 1-wire 'driver' routines, which we will call **1wire.asm**. Then there will be a different file that will hold the high level program, which calls the driver and does some useful work. We will call that **main.asm.**

Thinking about the design a little further, there will obviously be a need for some routine or routines to provide very precise delays. These could go in **1wire.asm**, but they are going to be very general purpose, and quite likely to be useful in another project. We will place any delay routines in a file **delays.asm**.

At this stage, there is one further improvement we could make: write higher level routines for accessing particular devices (such as **readeeprom** and **writeeeprom** in the case of the DS2430A) and store these in a file named after that particular device (**ds2430a.asm** for example). It's a good idea, but for clarity we will skip that step. So we will create three files:

**main.asm**
**delays.asm**
**1wire.asm**

## Delay timing

Referring back to Fig.1, it's clear that we need several delay times: 15$\mu$s, 60$\mu$s, 240$\mu$s and 480$\mu$s. While we could create routines to implement exactly those timing delays, it's much more flexible to produce a general purpose routine that can satisfy all the options. We do that by passing in the time delay required in the W register.

Performing accurate delays in assembly is quite easy, if you know how fast your processor clock is running, and you don't mind not being able to do other things (like service interrupts) while the delay is executing. We have created a simple **delay5us** routine that will delay for the number of multiples of 5$\mu$s specified in the W register. The routine is a little inaccurate at low delay times (it adds about 2.5$\mu$s additional time during the call) but will be perfectly suited to our needs.

The routine, along with all the other code, can be found on the *EPE* website download page (access via **www.epemag.co.uk**) in the *Pic N' Mix* folder.

## Sending data

Now we can time the delays for toggling the I/O pin up and down, it's time to look at the meat of the problem – sending data bits on the wire, as defined in **1-wire.asm**. We start with the initialisation of the hardware.

The natural state of the 1-write data signal is floating, pulled high by the pullup resistor that also serves to power the remote device(s). To achieve this, we set our chosen I/O pin, RB1, to an input. Nothing else is required.

As we mentioned before, there are four main activities required in our low level software: sending a reset signal, writing a '1' bit, writing a '0' bit, and reading the state of the bus. We will deal with these one at a time.

Sending a reset signal to the remote devices is really a three-staged procedure – the CPU drives the wire low for 480$\mu$s, waits for 15$\mu$s and then looks for a 'low' level on the wire for up to 240$\mu$s, indicating the presence of a device. The entire detection time takes 480$\mu$s, presumably to allow the remote devices time to finish their own startup activities. The code for this can be found in the routine **reset1wire**.

Writing '1' and '0' data bits to the bus is very straight forward: pull the line low for 5$\mu$s, then either keep the line low for a '0' bit or return the port pin to an input to allow the wire to rise high, signaling a '1' bit. After a delay of 55$\mu$s, the data line must be returned to the high level by setting the port pin to an input. These routines are called **write1bit** and **write0bit**.

Reading data from the bus (or, more correctly, from a device on the bus) is always initiated by the host microcontroller. To read a data bit you drive the bus low and then immediately release it. Then 15$\mu$s later, read the level on the wire to determine the bit value. Repeat for however many data bits need to be read. This routine has been called **read1wire**, and returns the value of the data bit in the W register.

These three routines, along with **reset1wire** and **init1wireHw**, completely define the code required to connect the software we write to the physical hardware. From now on, you can forget about what pin your devices are connected to; all higher level software will rely on these five routines alone. This is what software engineers call *abstraction*, hiding the complexity of the lower levels of software. It's an essential technique when you are working on large, complex programs.

## Finally

That about wraps it up for 1-wire interfacing; performing the actual read and write functionality is a simple case of calling the write and read functions in an order that matches the commands mentioned last month. The remaining routines in **1-wire.asm** implement the high level commands, such as reading and writing memory. The file **main.asm** contains some example calls to show how they all fit together.

Last, but by no means least, we must specify the value of the CONFIG register. Specifically for our example circuit, we must select the INTOSC option to enable the 8MHz internal oscillator. We do that in the main application file **main.asm**.

The example source code available on the *EPE* website's download page contains all the routines necessary to experiment with this interesting and low cost network interface.

## Brain teaser

There were some interesting responses to August's 'brain teaser' on alternative methods for generating random numbers. One in particular caught our eye, from **Godfrey Manning** in the UK:

*Here's a theoretical suggestion for hardware random-number generation, although I haven't tried it out in practice. An electro-mechanical buzzer generates electrical noise and a relay can be wired as a buzzer. The noise is then tapped off by inductive coupling and capacitively coupled to the next stage. Next come two possible means of signal processing to produce digital pulses, then two ideas as to what to do with them.*

***First possibility:*** *suitable Zener diodes limit the peaks, but it's no good having one to each rail as one will be like a normal forward-biased diode, depending on the polarity of the pulse. So the appropriate Zener diode comes into effect by having a Schottky diode (fast, but low-voltage-drop) in series with it, only allowing unidirectional conduction.*

*The signal, thus limited, is applied to the mid-point of a high-impedance potential divider (giving half-supply when quiescent), also one input of an op amp comparator. The other op amp input is fixed at half-supply. The op amp output therefore bounces from one rail to the other, depending on the polarity of the incoming voltage spike.*

*Passed through a Schmitt-triggered gate this produces a random pulse train.*

***Alternative processing:*** *a Zener diode limits positive peaks and a Schottky diode limits negative ones, which is then passed straight into a Schmitt-triggered gate.*

*First, a means of using this train of random bits: read the digital value n times, at each of* n *'ticks' of a regular clock pulse. These n readings then become the consecutive bits of an* n*-wide random number (this technique is like a UART serial-to-parallel conversion). So* n *would be eight for a byte value, sixteen for a word.*

***Alternative application:*** *a regular clock pulse is applied to the D (Data) input of a D-type flip-flop. Then the random bit stream clocks the flip-flop. At any given instant, the probability of a 0 or 1 entering the flip-flip is equal, but the random effect is that the moment of clocking is chosen according to the noise pulse train. Presumably, the flip-flop state is determined on the rising edge of the random clock. On the descending edge of the random clock, the Q output of the flip-flop must be captured and becomes the next bit to contribute to the* n*-wide final number.*

*The buzzer is an electromagnetic compatibility nightmare and must be in a screened enclosure! Power is taken into the screened box by feed-through capacitors with series inductors hard up against the outside terminal.*

Certainly an unusual suggestion, although potentially limited due to mechanical wear and tear over time if the random data is being accessed continuously. Commercial random number generator designs typically use the noise generated by electrons moving through a resistor or diode, amplified and then fed through a circuit not dissimilar to that which Godfrey describes above.

Thanks to everyone for their random number suggestions.

## New brain teaser

This month's teaser is an exercise in studying the Microchip website:

One of the features that the PIC10, 12, 16 and 18 families of processors share in common is that the rate at which instructions are executed (the instruction cycle time) is fixed at one instruction every four clock cycles. This is why it is so easy to produce accurate delay time routines in assembly languages.

Assuming your design had to operate at 5V, if you wanted to choose a processor in any of the above families that had the fastest rate of instruction execution, which one (or ones) would you choose? Would the voltage at which you ran the processor have an effect on your answer?

An honorary mention in a later article for the first correct answer. Submissions by email to **mike.hibbett@gmail.com** or in writing or by email to *EPE*.

If there is a subject that you would like to see covered in a future *Pic 'N Mix* article feel free to contact the author, either directly or via *EPE*.

## References


1. Application Note 132, **http://pdfserv.maxim-ic.com/en/an/app132.pdf**


**PLEASE TAKE NOTE**

**V2 PC Scope** *(August '07)*

Page 15, Parts List. The type number for IC7 and IC9 should read **LMC6482**. The circuit diagram Fig.2 is correct.

# Ingenuity Unlimited

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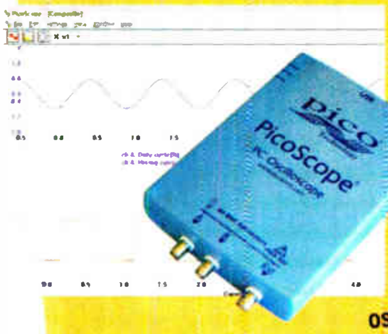

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## Monitoring PSU output current and voltage – *Minimising switch resistance*

When monitoring the output of a bench PSU it is convenient to use a single panel meter switched to read voltage or current. I used the simple circuit at Fig.1. Switch S1 selects the shunt R1 for current measurement and S2 selects the series resistance R2 for voltage.

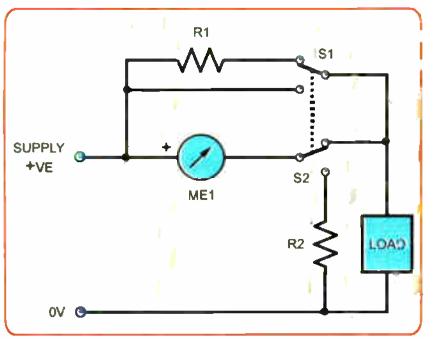



*Fig.1. Basic circuit for a power supply output current and voltage monitor*

But it was found that the current readings were inconsistent. The penny finally dropped when I realised that as resistor R1 has a low value, the 'on' resistance of switch S1 could be significant as they are in series. Measurement using a low ohms meter showed that the 'on' resistance of S1 varied between 10mΩ and 30mΩ, depending on how frequently it was operated.

A typical 100 microamp moving coil meter, scaled to read 1A, requires a shunt of about 150mΩ. If S1 adds 30mΩ or so to the shunt, this causes a positive reading error of about 20%. The effect is linear, so if S1 adds only 15mΩ the error will be 10%.

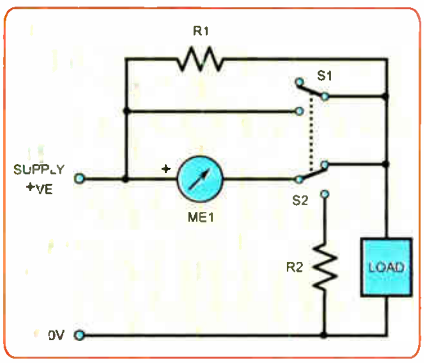



*Fig.2. Final simple add-on circuit for monitoring the output current and voltage of a bench power supply. Note switch S1 is no longer in series with shunt resistor R1*

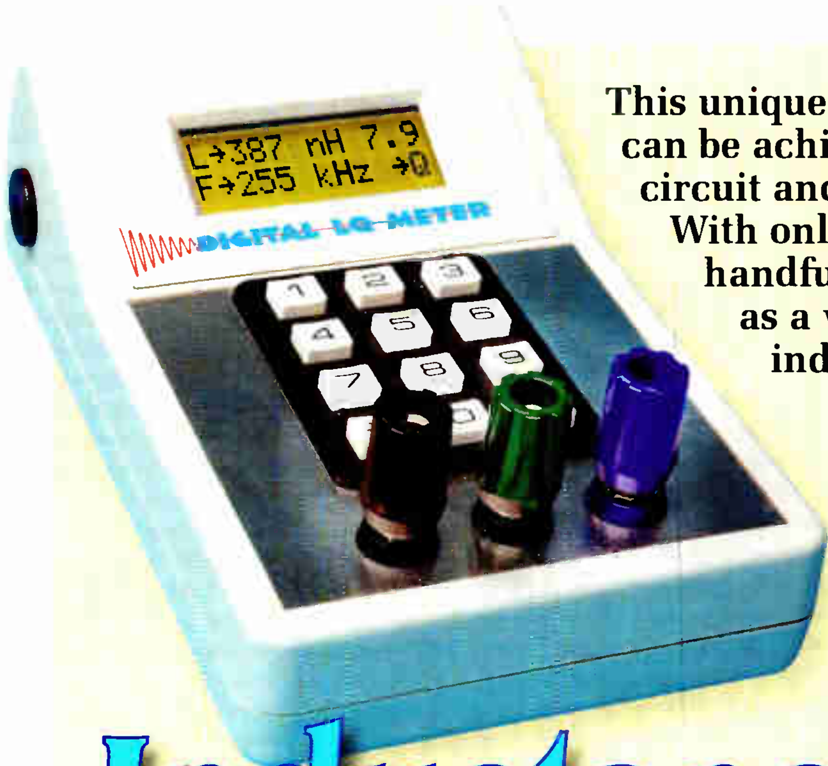
Modifying the circuit to Fig.2 solved the problem as S1 is no longer in series with the shunt R1. Switch S2's 'on' resistance has no significant effect as it is much less than either the meter coil or R2.

Incidentally, to find the shunt and series resistances R1 and R2 quickly, I use the formulas:

| *Voltmeter* | *Ammeter* |
|---|---|
| R2 = Rm(n - 1) | R1 = Rm/(n - 1) |

Where: Rm = meter coil resistance in ohms; n = voltage and current multiplication factors.

**Stephen Stopford, London**




**This unique project demonstrates what can be achieved with a relatively simple circuit and some clever programming. With only a microcontroller and a handful of components, it functions as a wide-ranging, multi-frequency inductance and Q-factor meter.**

# Inductance & Q-Factor Meter

**Pt.1: By LEONID LERNER**

INDUCTORS ARE UBIQUITOUS, being indispensable in circuits such as loudspeaker crossover networks, switchmode power supplies and RF amplifiers. Unlike other components, inductors are often hand-made, particularly when prototyping or assembling a do-it-yourself project. At a minimum, this suggests the need for a meter to check inductance values prior to use in circuit.

But that is not the end of the story. Of all the passive components, inductors typically show the greatest deviation from ideal behaviour. This is due primarily to coil resistance and the hysteresis of the core material.

The picture is further complicated by the fact that the losses are frequency dependent. The skin effect in copper wire and the complicated frequency characteristics of magnetic materials both come into play and are apparent even at audio frequencies.

To provide a more informative picture of inductor performance then, this meter allows you to measure the Q factor of a prospective resonant circuit at the operating frequency. If you've never heard of Q factor, then read on . . .

## Measuring L and Q

There are several basic methods of measuring the inductance (L) and the Q-factor of a tuned circuit, the most common being 'temporal' (time domain) and 'spectral' (frequency domain). The spectral method was described in the *Poor Man's Q-Meter* article in the June 2007 issue of *EPE*. It consists of applying a sinusoidal voltage of varying frequency to a resonant circuit and measuring the circuit response as a function of applied frequency.

The response of such a circuit will generally follow that shown in Fig.1, with a peak at a given frequency, dropping away on both sides in a bell-shaped curve. Circuit theory demonstrates that the peak angular frequency squared is just the inverse

## Specifications

**Range**
Inductance: 200nH - 10mH
Q-Factor: 1-120 (approx.)

**Power Supply**
9V DC 300mA plugpack

**Features**
(1) Internal or external tank capacitance facility for accurate Q measurements
(2) Measurement frequency autoranging up to 20MHz

of the inductance (L) times the capacitance (C). So if we know C, then the inductance can be found.

On the other hand, the Q factor is the ratio of the peak frequency to the width of the bell-shaped curve at half-power. This is how the Q is manifested experimentally. Theoretically, it is defined as the ratio of the circuit reactance to its resistance at resonance.

It should be emphasised that the preceding definitions are only approximations but give excellent results provided Q is greater than 2 or so. For heavily damped resonant circuits, the relationships between waveform and circuit parameters are more complicated. However, we are not interested in such circuits here.

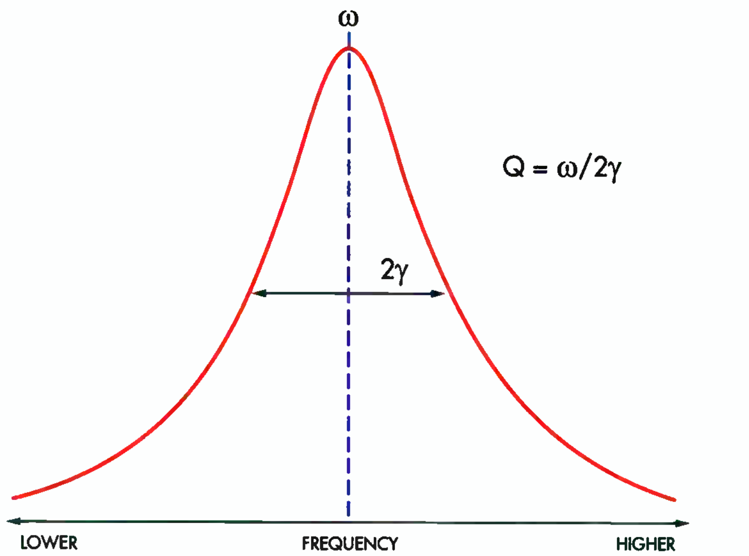



**Fig.1: the spectral response of a resonant circuit reveals a peak at a given frequency, dropping away on both sides in a bell-shaped curve. The Q factor is manifest as the ratio of the peak frequency to the width of the bell-shaped curve at half-power.**

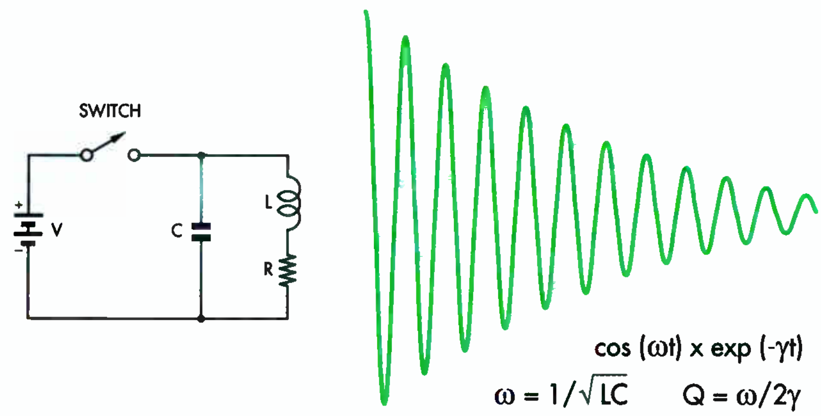



**Fig.2: the temporal method used in this design relies on decaying oscillations after a rectangular pulse is applied to the resonant circuit. The Q factor manifests as the ratio of the oscillation coefficient (the angular frequency) to twice the decay coefficient.**

## Temporal method

The temporal method of inductance measurement is adopted in this design. It is based on the fact that when a rectangular pulse is applied to a resonant *LCR* circuit, such as that shown in Fig.2, decaying oscillations give rise to a ringing waveform. These oscillations continue until all energy is dissipated in the circuit resistance, with their frequency the same as that at which the peak occurred in the spectral response. The Q factor in the temporal response manifests itself as the ratio of the oscillation coefficient (the angular frequency) to twice the decay coefficient.

We can use this information to measure the L and Q of a parallel-resonant circuit with a squarewave generator and a scope. The generator is connected to the tuned circuit via a large resistor, so as not to appreciably load the circuit and thereby alter the Q. This resistance should be larger than the series resistance multiplied by $Q^2$.

A typical oscilloscope trace of a ringing waveform set up in a resonant circuit by such a generator is shown in Fig.3. The period is the time required for the signal to undergo N oscillations, divided by N. The Q factor is the number of oscillations required for the peak amplitude (starting at some convenient peak) to drop to about 0.043 of its initial value. In practice, one can get better accuracy by counting the number of oscillations for the amplitude to drop to one fifth, and multiplying this number by two.

The above procedure is the basis for this project, with an AT90S2313 microcontroller performing the multiple functions of generator, scope and calculator. A liquid crystal display (LCD) and keypad are also included to provide a convenient means of setting basic parameters and observing the measurement results.

## Fourier transformed

It is interesting that one can get from the ringing waveform of the temporal response to the bell-shaped curve of the spectral response by a technique called the 'Fourier Transform', or its numerically useful form, the Fast Fourier Transform (FFT). This means one

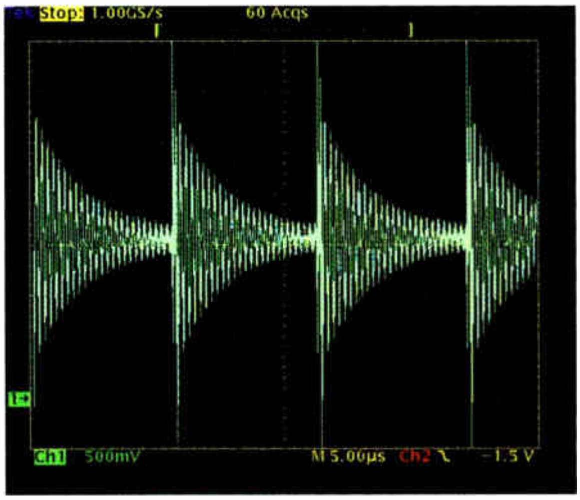



**Fig.3: this scope shot shows the response of an LCR circuit to an applied pulse. Decaying oscillations give rise to a ringing waveform, which continues until all energy supplied by the pulse is dissipated in the circuit resistance. The frequency of oscillation is the same as would occur at the peak in the spectral response.**

does not actually have to make spectral measurements in order to obtain the spectral response.

This is useful because it is much easier to extract the parameters of interest from the spectral plot than from the temporal plot. The former involves just finding a peak in the data, while the latter requires establishing and then counting the zero-crossings. Another advantage in using FFTs is that the effects of the inevitable analogue noise, as well digitising distortions, are minimised, as they are separated from the signal in the Fourier analysis.

Depending on circuit Q, our meter can measure inductances as low as 200nH and as high as 10mH. The range of Q measured varies from about 1 to 120. In addition, the meter indicates when both L and Q values are out of bounds (indicated by the letter 'E' on the display).

## Circuit basics

Before looking at the circuit operation in some detail, it is instructive to consider the block diagram in Fig.4. The central component of the system is an Atmel AT90S2313 microcontroller. This particular micro was chosen because it is relatively cheap yet includes all of the features needed to minimise the total component count.

The micro controls a 'pulser', which is used to excite a tank circuit. The tank circuit consists of the inductor under test and a paralleled capacitor. The capacitor can be selected by the user and connected externally. Alternatively, one of three internal capacitor values can be chosen from the keypad.

To minimise loading and compensate for circuit losses, the waveform from the tank circuit is buffered and amplified by an op amp. Following this, it is fed into a sample-and-hold (S/H) circuit and then into an analogue-to-digital converter (ADC).

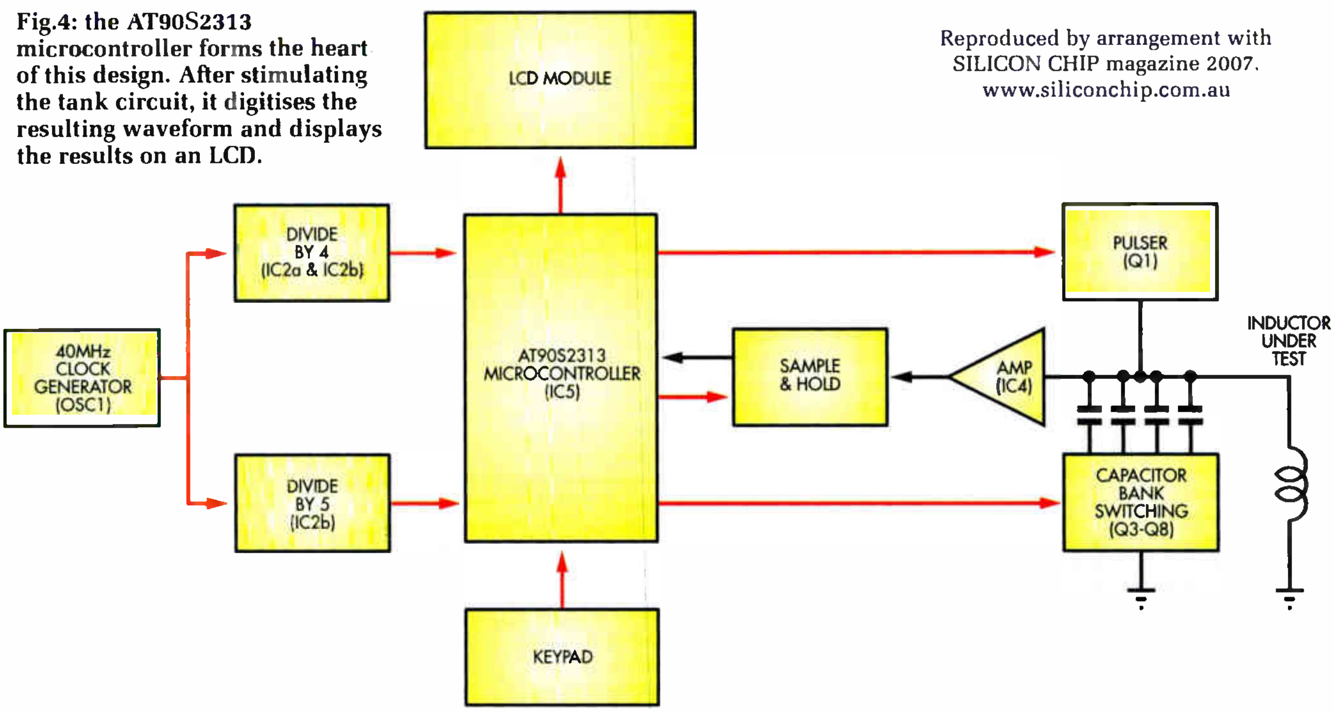
The ADC functions are contained mostly within the micro so they do not appear on the block diagram. A ramp converter was chosen for its simplicity and low cost. For readers not already familiar with this type of converter, its operation can be summarised as follows:

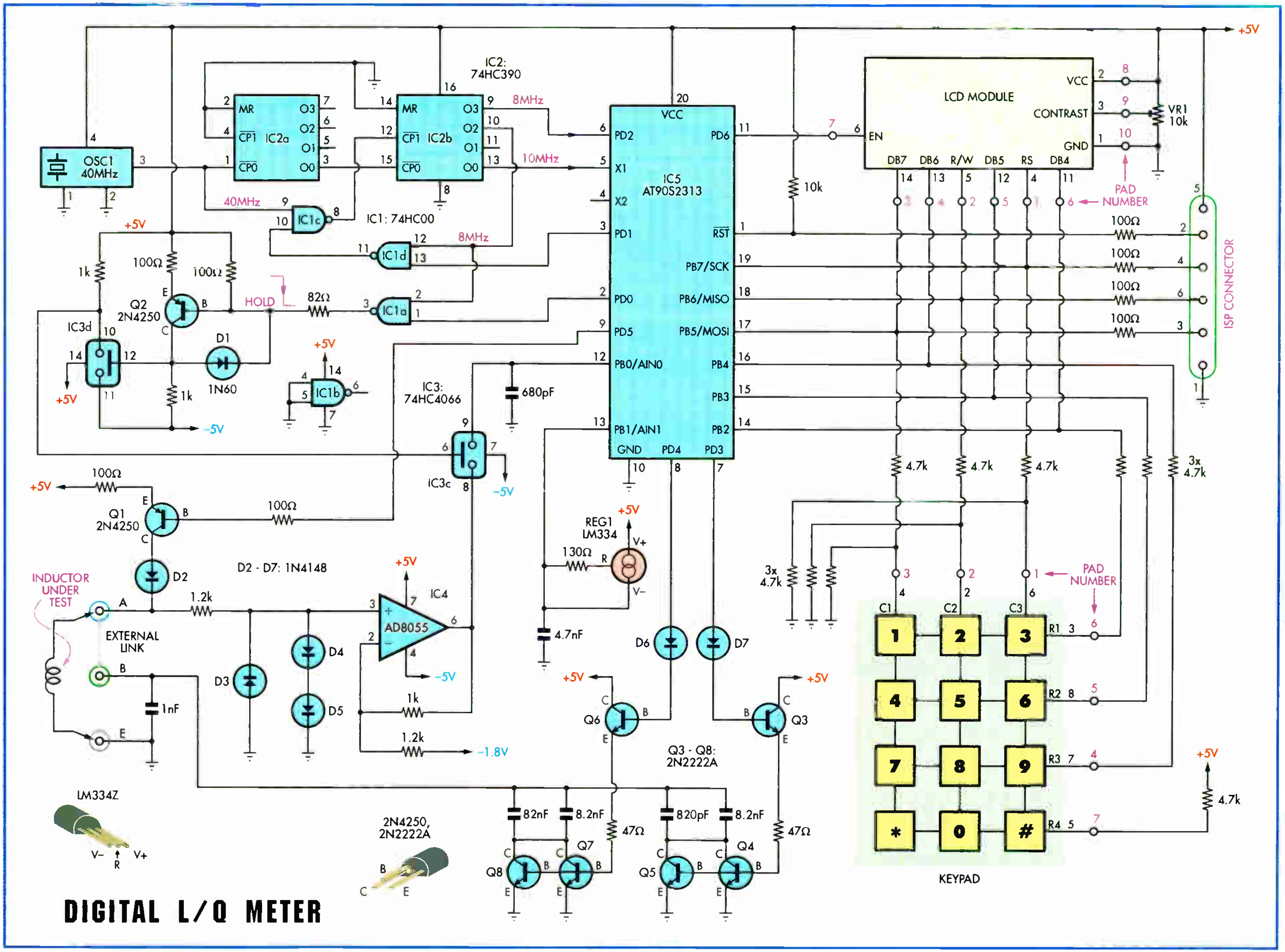
A conversion cycle begins with the charging of a capacitor from a constant-current source. As the capacitor begins to charge, a binary counter starts counting from zero. The increas-

**Fig.5 (right): complete circuit diagram (minus power supply) for the meter. A high-speed sample and hold circuit made up of a simple counter (IC2), analogue switch (IC3) and some clever programming allows the meter to measure resonant circuits at frequencies up to 20MHz.**

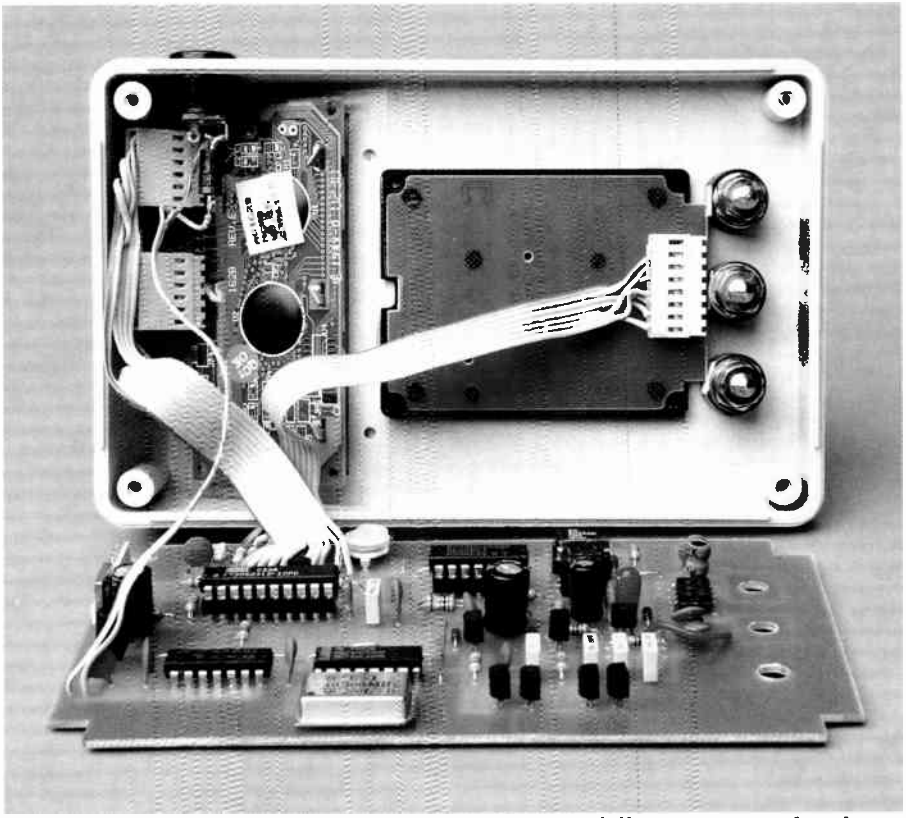
**Fig.4: the AT90S2313 microcontroller forms the heart of this design. After stimulating the tank circuit, it digitises the resulting waveform and displays the results on an LCD.**








DIGITAL L/Q METER



**This is the view inside the completed prototype. The full construction details will be published in Pt.2, next month.**

ing capacitor voltage (the 'ramp') is continually compared with the input voltage. When the two voltages are equal, the comparator stops the counter, whose count is then proportional to the input voltage.

Although simple. ramp converters have a comparatively long conversion time and a somewhat reduced precision. In this application, precision is not of particular concern since it is the time characteristics of the signal that are of paramount importance.

However, conversion time *is* important. Inductors in the order of a few hundred nanohenries require measurement frequencies of tens of megahertz to achieve a sufficiently large Q and so an accurate measurement. This is clearly well beyond the capabilities of our simple ramp converter. Even if the design was to use a dedicated high-speed (20MHz or better) ADC. the micro would not be fast enough to store the results of each conversion.

All this overlooks the fact that the ringing waveform is repetitive. It can, therefore, be digitised at low speed by repeatedly stimulating the tank circuit and measuring each waveform at progressively larger offsets from time zero.

To achieve the desired 20MHz sampling rate, measurements must be made at 25ns intervals. This is achieved with the aid of a programmable sample-and-hold block which holds each measurement long enough for the low-speed ramp converter to complete its task.

## Detailed operation

The circuit diagram for the majority of the L/Q Meter appears in Fig.5. Let's start at the test terminals, where the inductor under test and capacitor(s) are connected to form the tank circuit.

Transistor Q1 is used to pulse the tank circuit. It is driven via a 100Ω current limiting resistor from output port bit PD5 (IC5, pin 9). A second 100Ω resistor in the emitter (E) circuit limits peak pulse current to about 50mA. Diode D2 provides isolation between the tank circuit and the driver so as not to dampen the oscillations.

Installing a shorting link between the 'A' and 'B' terminals links the inductor under test with an internal set of capacitors. A 1nF capacitor across the terminals fixes the minimum capacitance. Two other capacitor values (10nF and 100nF) can be switched into the circuit under program control using port bits PD3 and PD4 (IC5, pins 7 and 8).

Signals from these pins are fed through isolating diodes D6 and D7 to current amplifiers Q3 and Q6 and from there to switching transistors Q4/Q5 and Q7/Q8. Two medium-current transistors are used in parallel to reduce the dynamic collector-emitter resistance and hence its influence on the circuit Q. Even so, the transistors contribute about 0.5Ω series resistance and the influence of this on the Q should be borne in mind.

Relays could have been used to reduce the series resistance further. However, these are slow, prone to failure and not really in accord with our solid-state approach. In addition, the use of high-current audio transistors is precluded by their high output capacitance. If there is some concern about the contribution of the internal circuitry to the Q factor then you can leave out the link and use an external tank capacitor.

## Fast op amp needed

So as not to load the tank circuit, the output signal is buffered by an op amp (IC4), which is connected in a non-inverting configuration for high input impedance. An AD8055 op amp was chosen for the task as it has a high gain-bandwidth product and high slew rate and is stable when driving capacitive loads at low gains. Lower spec op amps are not suitable here, as they would severely limit the frequency range of the meter.

Ideally, the output from the op amp should swing between about 0 to 4V maximum, which is the maximum input range of the comparator. To this end, op amp gain is set to about 1.8 by the 1.2kΩ and 1kΩ resistors, counteracting losses in the circuit.

To maximise dynamic range and minimise the influence of noise and digitisation errors, the AD8055 and analogue switch (IC3) are powered from ±5V supplies. Furthermore, the inverting input of the op amp is biased at −1.8V, meaning that the output (pin 6) will swing either side of +1.8V. This scheme makes the most of available headroom, which is limited to about 3.7V. Note that the micro is programmed to reject the initial part of the ringing should saturation occur.

## Hold it a moment

The output of the op amp drives a high-speed sample-and-hold circuit

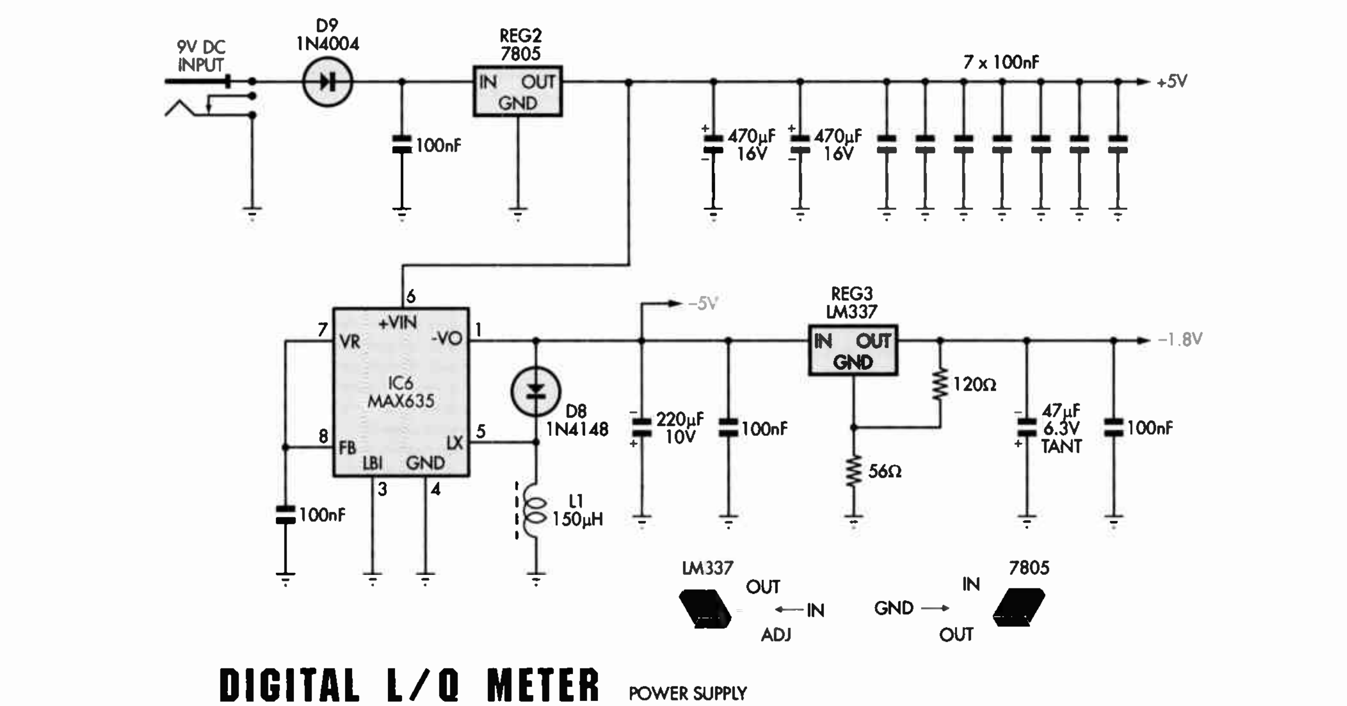



**Fig.6: the power supply section. A conventional +5V regulator (REG2) powers the entire circuit, while a switchmode inverter (IC6) generates −5V for some of the analogue circuitry. An LM337 negative regulator (REG3) is used only to generate a bias voltage for op amp IC4.**

ahead of the comparator (ADC) input on pin 12 of the microcontroller. The S/H circuit consists primarily of an analogue switch (IC3c) and a 680pF storage capacitor.

As mentioned earlier, the micro digitises a measurement by repetitively sampling successive waveforms. Samples are taken at incremental offsets from time zero to build a complete and accurate digitisation of the ringing waveform.

Sampling begins by closing the analogue switch (IC3c) at time zero. After the programmed delay, the switch is opened, leaving the 680pF storage capacitor charged to the waveform voltage at that instant. Our slow ADC then has sufficient time to digitise the voltage, after which it is stored and the cycle repeats. This is represented graphically in the scope shots of Figs.7a and 7d.

Unfortunately, the 100ns cycle time of the micro means that it is too slow to directly control the analogue switch (IC3c). With a maximum 20MHz sampling rate, we need 25ns resolution. This is provided by external logic, consisting of a 40MHz oscillator module (OSC1), timing circuits (IC1 and IC2) and a level converter (Q2, D1, IC3d, etc), all under control of the Atmel microcontroller (IC5).

## Level conversion

Let's look at the level converter circuit first. It consists mainly of transistor Q2, diode D1 and analogue switch IC3d. The sole purpose of this circuit is to convert the 0 to 5V levels from the NAND gate output (IC1a) to ±5V levels to control the S/H switch (IC3c).

Since the minimum sample time is only 25ns, Q2 is required to switch in nanoseconds and have a slew rate in the order of 1000V/µs. This is achieved with the use of a high beta transistor and 100Ω resistors in the base-emitter circuits, as well as the germanium diode (D1) between the collector and base. The results can be seen in the oscilloscope trace of Fig.7a.

Q2 inverts the control signal from IC1a, so a spare analogue switch (IC3d) is used to invert it again before it is fed to the control pin of the S/H switch.

## Timing secrets

The two divide-by-2 sections of a dual decade counter (IC2) are cascaded to divide the 40MHz clock down to 10MHz for the micro's clock input on pin 5. The divide-by-5 section of the second half of the decade counter (IC2b) is used to derive two out-of-phase 8MHz timing signals.

Output 3 (bit 2) of the counter (pin 9) is used by the micro as an 8MHz synchronisation signal. It is high during only one state of the five states of the counter, allowing precise determination of the instantaneous state of the 8MHz clock with respect to the 10MHz clock.

Output 2 (bit 1) of the counter is NANDed with port bit PD0 (pin 2) of the micro via IC1a to generate the 'hold' signal for the S/H circuit. As the micro's port outputs are synchronised to its 10MHz clock, the difference between the rising edges of the two signals on IC1a's inputs allows generation of 0ns, 25ns, 50ns and 75ns delays under program control. This can be seen in the simplified timing diagram of Fig.8.

Output 2 is also NANDed with port bit PD1 via IC1d so that the micro can freeze the counter. Note that Output 2 is used here instead of Output 1 as it goes high earlier in the counting cycle, thus allowing for the propagation delay through gates IC1c-IC1d and IC2b.

## Digitising

The micro program performs analogue-to-digital conversions by using the AT90S2313's internal comparator

## How The Ringing Waveform Is Digitised

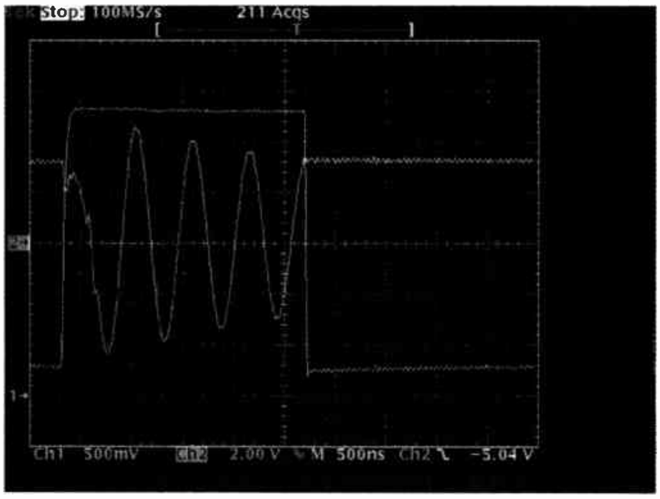



Fig.7a: the following series of scope shots were captured at progressively longer timebase settings and provide an insight into how the ringing waveform is digitised. Here, the green trace shows the waveform at the S/H output (pin 9 of IC3c), while the red trace shows the control signal on pin 6. Note the very fast transitions of the latter, which for the all-important trailing edge (hold) constitutes 7ns, or 1400V/µs. The waveform is oscillating at a 1.8MHz rate and its instantaneous value is captured when the control signal goes low. Also, note that the voltage at the S/H output doesn't decay noticeably during the hold period (red trace low), when the analogue-to-digital conversion takes place.


Fig.7b: a waveform is acquired by continuously stepping the delay between the pulse applied to the tank circuit and the hold signal. The rising plateaus generated by successively greater delays capture the rising edge of a particular sinusoidal cycle and show how a repetitive 1.8MHz signal is effectively frozen and reproduced on a much larger time scale. Note that the hold period or the time interval between successive pulses, reflected in the length of the plateaus, increases with increasing voltage. This is because the conversion time of the ramp converter is proportional to the sampled voltage.

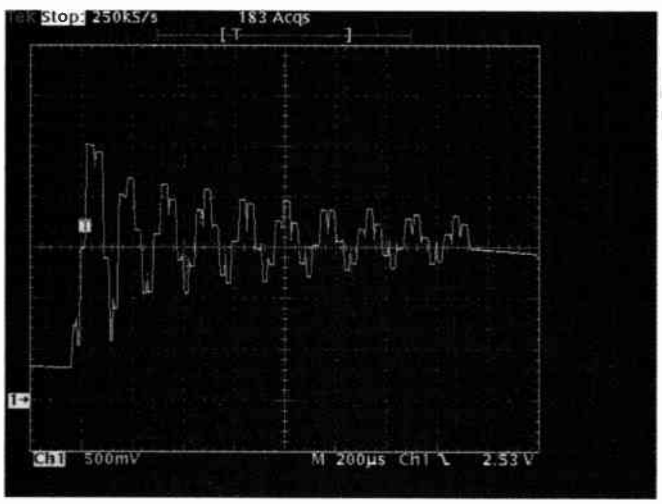



Fig.7c: with a timebase of 200µs/div, the sample-and-hold control signal is now just a succession of spikes and is not shown. At this time scale, the sequence of flat plateaus reproduces a digitised version of the original ringing waveform of Fig.7a, occurring at a rate almost 1000 times faster.

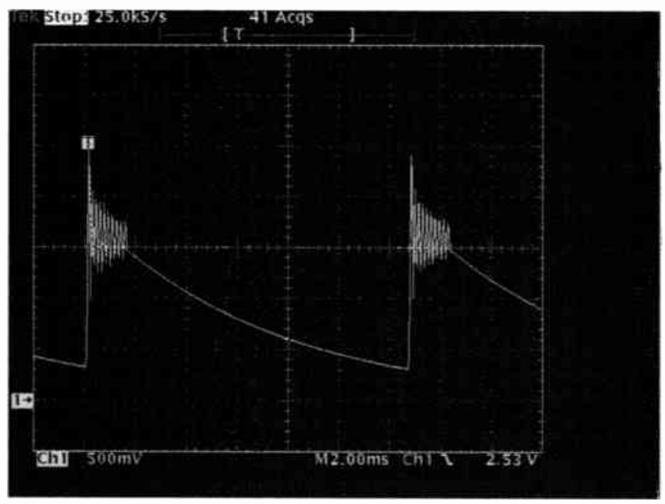



Fig.7d: this final shot is at the longest timebase setting (2ms/div). Each bunch of oscillations is the digitised ringing waveform in the previous figure. Between acquisitions the micro performs calculations, so the S/H circuit is idle and the charge on the 680pF capacitor decays.

in a ramp converter. This requires a voltage rising at a constant rate to be produced at the inverting input of comparator IC5 (pin 13). This is produced by an LM334 constant current source (REG1) which is used to charge a 4.7nF capacitor.

The LM334 provides temperature compensation in this time-critical part of the circuit.

The input signal (via the S/H circuit) is applied to the non-inverting input of the comparator (pin 12). The output of the comparator is programmed to trigger a counter interrupt inside the

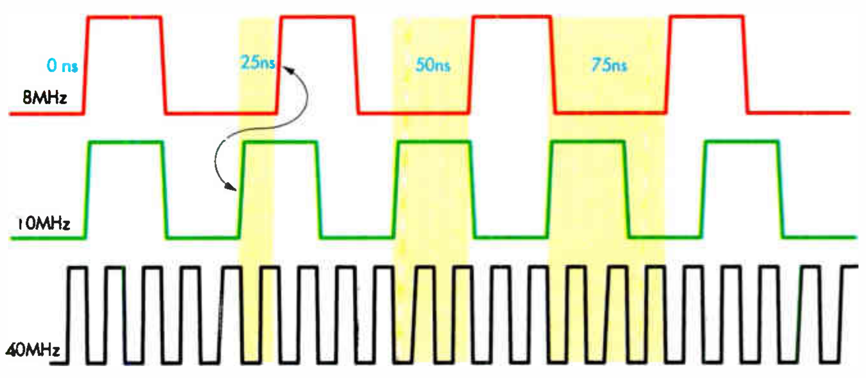



**Fig.8: the time difference between the rising edges of 8MHz and 10MHz clock signals are exploited to enable high-speed sampling. The micro latches a high on PD1 (pin 3) on the rising edge of its 10MHz clock and after a 0, 25, 50 or 75ns delay, the rising edge of the 8MHz clock freezes the input voltage at that instant.**

AT90S2313 when the ramp voltage exceeds the input voltage.

Note that the LM334 is rather slow compared to the speed of the rest of the circuit, so current is not switched at its input terminal. Instead, switching is performed at pin 13 of the micro, which is connected to an internal pull-down transistor. This shunts current from the LM334 until the conversion commences.

Once enough of the waveform is acquired, the microcontroller performs an FFT of the sample and finds the spectral peak. The FFT is a complicated mathematical procedure and is quite computationally intensive. It is therefore usually performed on high-speed floating-point processors, such as Intel's Pentium class and above.

However, speed is not of paramount importance in this application. More importantly, the results must be accurate and this was confirmed by comparing the results of two FFTs, one performed on a Pentium and the other on an AT90S2313.

## Display and keypad

A 2-line × 16-character LCD module, keypad and ISP (in-system programming) interface to the micro via port B (PB2 to PB7) and one bit of port D (PD6). A number of port B lines are shared between devices. The LCD module is interfaced in 4-bit rather than 8-bit mode, so only its upper data lines (DB4 - DB7) are connected.

The keypad has 12 keys, organised in a matrix of 4 rows × 3 columns. The micro pulses each row in turn and polls the columns to determine which key is being pressed. Note that 4.7kΩ resistors are included in series with all the keypad lines to protect the port pins. This means that if a key is pressed while the micro is updating the LCD, no harm is done.

## Power supply

The power supply section of the L/Q Meter appears in Fig.6. Starting at the DC input socket, diode D9 provides reverse polarity protection ahead of a 7805 positive voltage regulator (REG2). This regulator provides +5V for the entire board.

As explained earlier, −5V is also needed for op amp IC4 and the analogue switch (IC3), and this is generated from the +5V rail by a MAX635 switchmode voltage inverter (IC6). As shown, this device requires only a diode (D8), inductor (L1) and filter capacitor to function as complete switchmode inverter.

The −5V rail is reduced to −1.8V by an LM337 negative voltage regulator (REG3). The 120Ω and 56Ω resistors between the GND and OUT terminals set the output voltage to −1.8V, to be used as a bias voltage in the op amp circuit.

## Next month

That's all we have room for this month. Next month, we will give the full construction details and describe how the Inductance & Q-Factor Meter is used.

*EPE*

## Out Of Bounds Detection & Display

The meter measures frequency and decay constant, so L and Q are derived quantities. This means that a Q value will be out of bounds when the meter cannot acquire sufficient periods of oscillatory decay to reliably calculate a decay constant.

This can occur for one of three reasons: (1) the Q is too low; (2) the Q is too high, so that negligible decay is observed on the scale of several hundred oscillations; or (3) the decay occurs on a very large time scale outside the range of the meter (this can occur when the measured frequency drops to several tens of kilohertz).

Note that an out-of-bounds Q does not automatically indicate that L and *f* are also unobtainable. These parameters will continue to be displayed, although their precision generally drops to around 10-20% of nominal. If no stable value for *f* can be had, then the L and *f* displays will blank out and a sole 'E' will show in the Q position.

Constructors should also be aware that LC circuits can have parasitic oscillations. If these are large, they can register as an incorrect value for L. This occurs because some inductors cannot be well approximated by a simple theoretical L, so there is no unique answer to 'what is the value of this inductor?'.

Nevertheless, the value derived from the frequency of oscillation with a given capacitor is a perfectly legitimate result, though if one were to make measurements at other frequencies, or use V = L x dI/dt to get L, a different answer could be obtained.

In other words, some thought must be given to the details of the measurement, rather than relying solely on the instrument to produce the magic number!

# The Power of Mechatronics

## Part Five – A New Dimension by Ian Pearson

In the last issue we introduced the concept of the Virtual Demonstration Board (VDB) in the context of adding speech interaction to a system. This was achieved using the Proteus VSM development tool from Labcenter Electronics (see back cover).

This month we will continue in a similar vein, but we will look at some of the other capabilities the Proteus VSM tool can offer. Our theme is Mechatronics, which involves interaction with sensors and mechanical components. Traditionally, this is difficult to achieve without physical hardware. We will, therefore, look at the implementation of the PICDEM Mechatronics Development Board in a virtual development environment.

### Virtual development

A virtual development board provides a means to perform system development without needing hardware. However, the aim is not to exclude hardware completely, that is after all the end goal of any design cycle, but to help reduce the total design cycle time. If we can reduce the number of hardware iterations required to reach a final design then we should be able to save time and crucially cost.

While we are trying out new ideas, or want to understand how a particular function works before we invest the time building a prototype, we can make use of the mixed mode simulation provided by the combination of MPLAB IDE and Proteus VSM. This will often prove more productive than creating a breadboard, soldering wires and checking connections, only to find you need to change a component during your first test, moments after building the board.

The use of the system simulator helps to reduce this cycle as the component change becomes a simple replacement, or a change of value in the schematic capture interface. An example simulation on a PC screeen is shown in Fig.1.

Once we have a design and are learning how the design functions we can make use of the virtual instruments, voltage and current probes and graph functions provided by the system simulator. These are all functions which can be provided

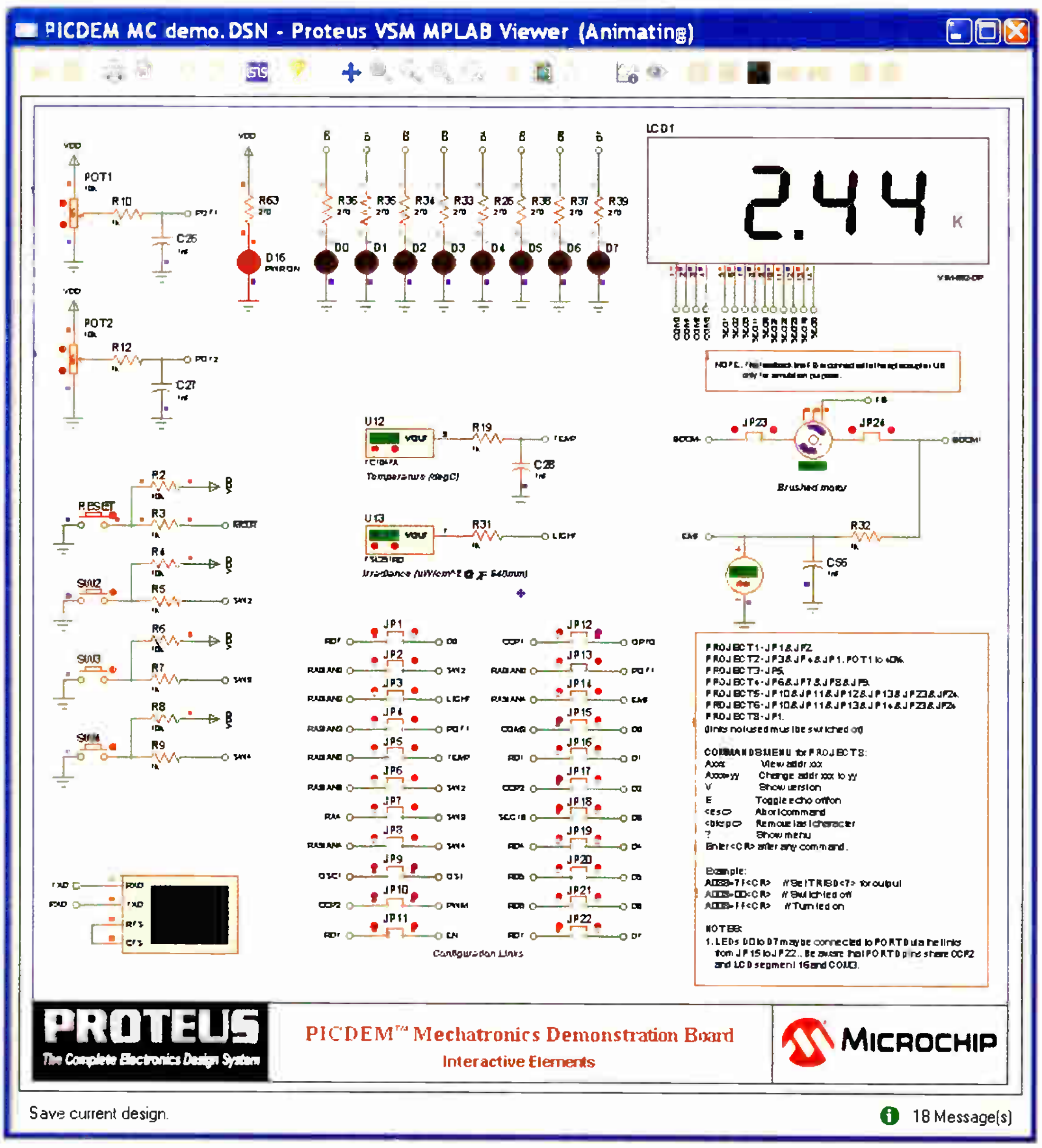



Fig.1. PICDEM Mechatronics demo board running a DC motor and back-EMF measurement and control (Project 6).

by hardware, but often at significant expense. In a mixed mode system we may wish to add an oscilloscope, maybe a logic analyser, log a voltage against time, add a protocol analyser for I²C or SPI. All of these are added quickly and easily to the design and help us to refine our system saving time and effort.

This is all very well, but these are all electronic components and we are creating a mechatronic system. We want to add a display, maybe a motor, surely we can't simulate these, can we? The benefit of the Proteus VSM simulator is that it allows you to add a number of electromechanical components, sounders, displays and models of sensors. This allows us to perform a full system simulation.

A major benefit from a software development perspective is the ability to perform operations such as range testing of a sensor. If, for instance, we wanted to test the full operating range of a temperature sensor, how difficult is it to create an environment in which we can re-create a −40°C to +125°C operating range.

In the case of the mechatronics board we have a light sensor, this again would be difficult in a real world environment to create and test a specific set point. We can, of course, bypass the sensor and use a voltage source, but this requires us to manually convert the voltage source to temperature so we can cross refer the test. Using the system simulation method makes this much easier. Examples are given in Fig.2 and Fig.3.

The virtual instrument and ground terminal can be added from within the MPLAB viewer by right clicking and choosing **Place -> Instrument -> DC Voltmeter**.

The examples allow us to easily cross compare an expected reading with the output voltage reading from the ADC. The up and down buttons on the sensor are used to adjust the displayed value and hence the output voltage. Once the values have been set up, the instrument can be wired up, all without leaving MPLAB.

So, at this point, the virtues of system simulation should be apparent. Let's take a look at what we can do with the PICDEM Mechatronics VDB.

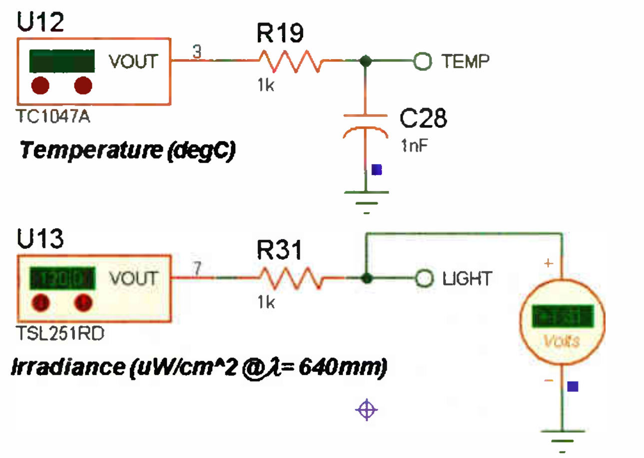



*Fig.2. The virtual sensors with additional virtual instrument to compare output voltage with stated value.*

## Using the VDB

Before we start using the demo board we need to make sure we have both MPLAB and the relevant version of Proteus VSM installed. You will need to use MPLAB V7.60 or greater and the demo version of Proteus at V7.1 SP4 or above. You may, therefore, need to download the latest version from the MPLAB page on the Microchip website at **www.microchip.com/mplab**, from where both MPLAB and the demo version of Proteus VSM are available.

Alternatively, if you have already installed Proteus from the CD provided with your May edition of *EPE*, then you can use the update manager to obtain the latest release of the demo version. This update process is necessary to ensure you have the latest library and part models, plus the demo code design for the PICDEM Mechatronics board. (The Mechatronics Demo Board and model of the PIC16F917 were released in the period between printing of the CD and release of this article).

So what can we do with a virtual demo board? This board offers a representation of a physical system. It differs in that some of the components we would normally expect to see on a design, such as power components and connectors, may be omitted. This can be for purposes of clarity or, if no annotation to PCB is to be performed, we can omit components as we need only include those devices required to perform our simulation.

If we subsequently decide to improve the capability of our system and create a PCB we can add the necessary components. The act of omitting components also helps to improve simulation time as there is less computation to perform. If we do decide to add all necessary components to create a physical PCB, then we can set the properties on a component to exclude it from simulation. This has the same effect as omission from a simulation perspective, but provides all of the necessary data for system creation.

In the same vein as exclusion from simulation, we can also exclude items from the PCB. This is useful where we have added components or instruments to aid simulation which would not be required on a final system. The examples that follow are all based around the standard demo package released with the PICDEM Mechatronics Demo Board hardware. To this we add the schematic design file for the Proteus VSM simulator which, combined with MPLAB IDE, allows us to perform our system level simulation and debug. This approach allows us to perform a comparison between the functionality that can be achieved with a virtual system and physical hardware.

We can debug in much the same way as we would with hardware tools using breakpoints. The physical hardware state is frozen at the breakpoint, unlike in hardware. This allows us to confirm hardware operation and step through actions to confirm code without losing the hardware status. See Fig.4.

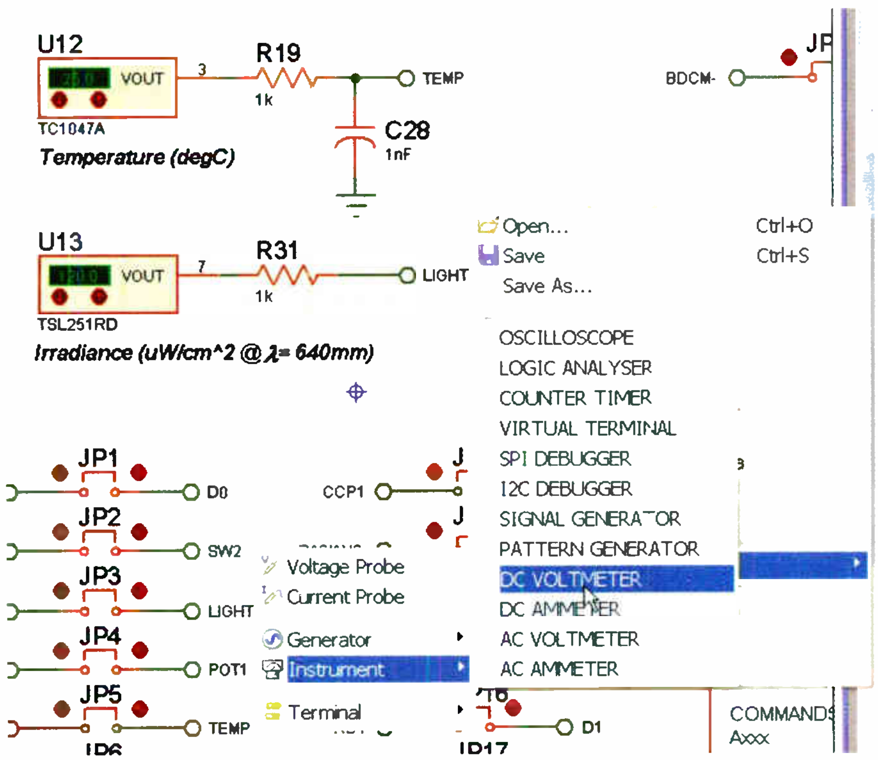



*Fig.3. The virtual instrument and ground terminal can be added from within the MPLAB viewer.*

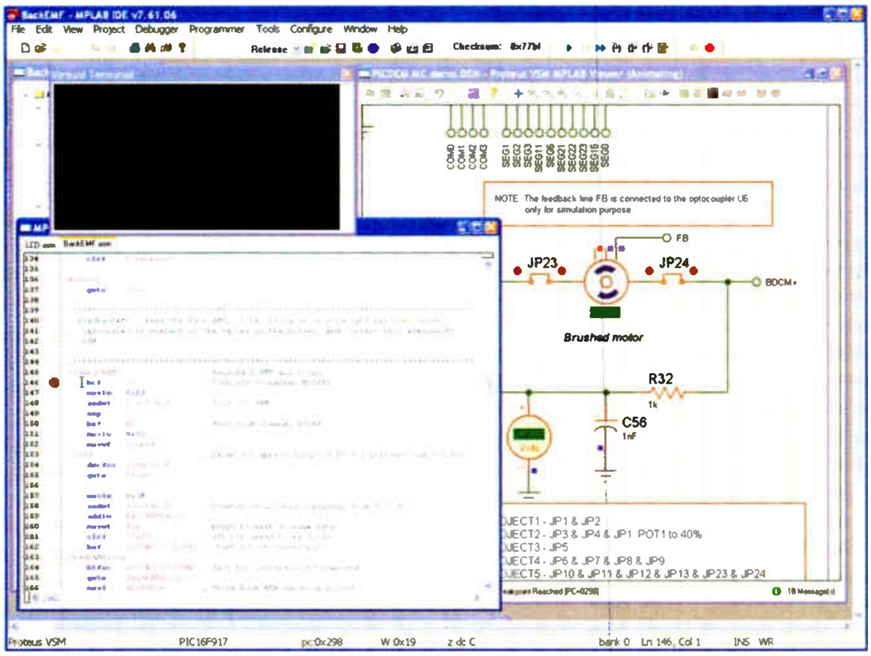



*Fig.4. Example of a debugging screen.*

All of the software examples are written in MPASM. It is possible to write your own applications using the C language because the Hitech PICC Lite compiler is now bundled in the installation for MPLAB V7.62 and later. At the time of writing, however, the examples have yet to be ported to the PICC Lite compiler.

## Device options

The device provided on the VDB is the PIC16F917. This device is a member of the mid-range architecture family and is one of the more peripheral-rich devices in this product group. The benefit that this provides is that we can use the high functionality, large pin count devices to develop our system. Once we have achieved the functionality we require, it is then possible to assess if we can use an alternative device in the family, which may be more suitable from a cost, size or other requirement.

As devices in the family groups share the same architecture and instruction set, and largely the same peripheral set, then migration to a different device is made significantly less difficult. Certainly, the physical Mechatronics Demo Board is laid out to accept 40-pin and 20-pin devices from the mid-range family of devices. The PIC16F917 allows us to complete all of the projects, except Project 9, which uses the more advanced ECCP module of the 20-pin PIC16F690.

The tasks we can perform in our virtual simulation take us from basic interaction, using digital I/O to reading a switch position and subsequently illuminating an LED; through using the ADC to read sensors; output of data to a direct drive segment-based LCD using the on-board LCD controller module and the ability to drive a virtual DC motor with the on-board capture, compare and PWM (CCP).

When approached from the perspective of using a more functional device in a virtual environment, we can very quickly achieve success and determine if our system is feasible. Once the initial design concepts are achieved we can quickly determine if we need to add functionality and move to a better, more functional device or, alternatively, if we need to, move to a more cost-optimised device.

The move to a cost-optimised design may require us to create the equivalent of a hardware module using software and I/O. Using the virtual approach, we can quickly make these changes and perform comparisons using the built-in analysis tools. Once we feel we have narrowed down the design we can perform our first hardware build. This method should then save us a significant amount of time and effort and hopefully allow us to get our product to market much earlier.

The limitations enforced with the demo version of the simulation system are that we cannot alter the schematic. It is node locked, so components cannot be added or removed. We can add instruments to help us perform our debug but we are limited to the equivalent of a non-alterable piece of hardware.

This restriction aside, we do obtain a fully functional virtual equivalent of the PICDEM Mechatronics board. We can use this to perform all of the standard labs provided and we can make use of the virtual instruments and graphs to help us observe and learn about what is happening on the circuit, without the immediate need to invest in hardware tools.

A further limitation is that the exact part we require may not be modelled. If this is the case, then requests for new models can be made to Labcenter or we can make use of the approach outlined above using a more functional superset level device and choosing the functionality we need on that device to create our design.

## Using the VDB

Once we have both MPLAB IDE and Proteus VSM installed we need to open our project. Within MPLAB IDE choose **Project > Open** and then navigate to the PICDEM MC Demo folder in **C:\Program Files\Labcenter Electronics\Proteus 7 Demo\Samples\VSM MPLAB Viewer\Eval Boards**.

Here you will find the PICDEM MC demo and a number of other VDBs which can also be tried. Alternatively, you can download the support package from the *EPE* website (access via **www.epemag.co.uk**).

To help you perform the exercises and use the mechatronics VDB you should download the user guide for the PICDEM Mechatronics board, also available from the *EPE* website. There is also a quick link to the mechatronics demonstration kit via **www.microchip.com/mechatronics**.

The PICDEM Mechatronics PCB is a very functional development board and as

PROJECT1 - JP1 & JP2.
PROJECT2 - JP3 & JP4 & JP1. POT1 to 40%.
PROJECT3 - JP5.
PROJECT4 - JP6 & JP7 & JP8 & JP9.
PROJECT5 - JP10 & JP11 & JP12 & JP13 & JP23 & JP24.
PROJECT6 - JP10 & JP11 & JP13 & JP14 & JP23 & JP24
PROJECT8 - JP1.
(links not used must be switched off)

COMMANDS MENU for PROJECT 8:
Axxx View addr xxx
Axxx=yy Change addr xxx to yy
V Show version
E Toggle echo off/on
<esc> Abort command
<bkspc> Remove last character
? Show menu
Enter <CR> after any command.

Esample:
A088=7F<CR> // Set TRISD<7> for output
A008=00<CR> // Switch led off
A008=FF<CR> // Turn led on

NOTES:
1. LEDs D0 to D7 may be connected to PORTD via the links from JP15 to JP22.. Be aware that PORTD pins share CCP2 and LCD segment 16 and COM3.

*Fig.5. Jumper settings aide memoire*

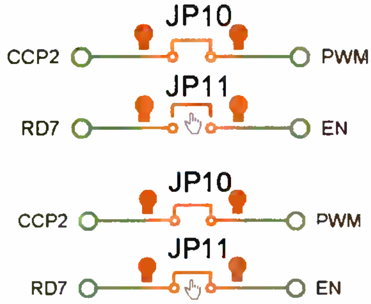



*Fig.6. Jumpers are default open as the demo board is generic to all projects, to engage a jumper, simply click on it.*

such does require a number of jumper changes to be made to route functions between a device pin and board function. To keep the number of design files to a minimum, this approach has been repeated on the VDB using an active link. To help understand which links need to be used for each project an *aide memoire* is provided on the schematic sheet, as shown in Fig.5 and Fig.6.

The *PICDEM Mechatronics Demo Board User Guide* provides a good reference to work your way through each of the labs provided, discussing what is being performed and the board setup to achieve the function required.

## Development tools

MPLAB V7.62 includes bundled compilers from CCS and HiTech. Of particular interest is the HiTech PICC Compiler for the Mid-Range Family of PICs and it specifically supports the PiC16F917. The compiler is a *lite* version and is therefore limited to a range of supported devices and also some of the device capabilities are restricted. All of the base line PICs and a number of Mid-Range PICs are supported.

For the 16F917 this limitation is to one page of program memory and two banks of RAM, thus providing a code space of 2K words and 176 bytes of RAM. Given the scope of the demonstrations this quantity of memory is however more than adequate. Full details of the PICC Lite C Compiler can be found on the HI-TECH website at **www.htsoft.com/products/compilers/PICClite.php**.

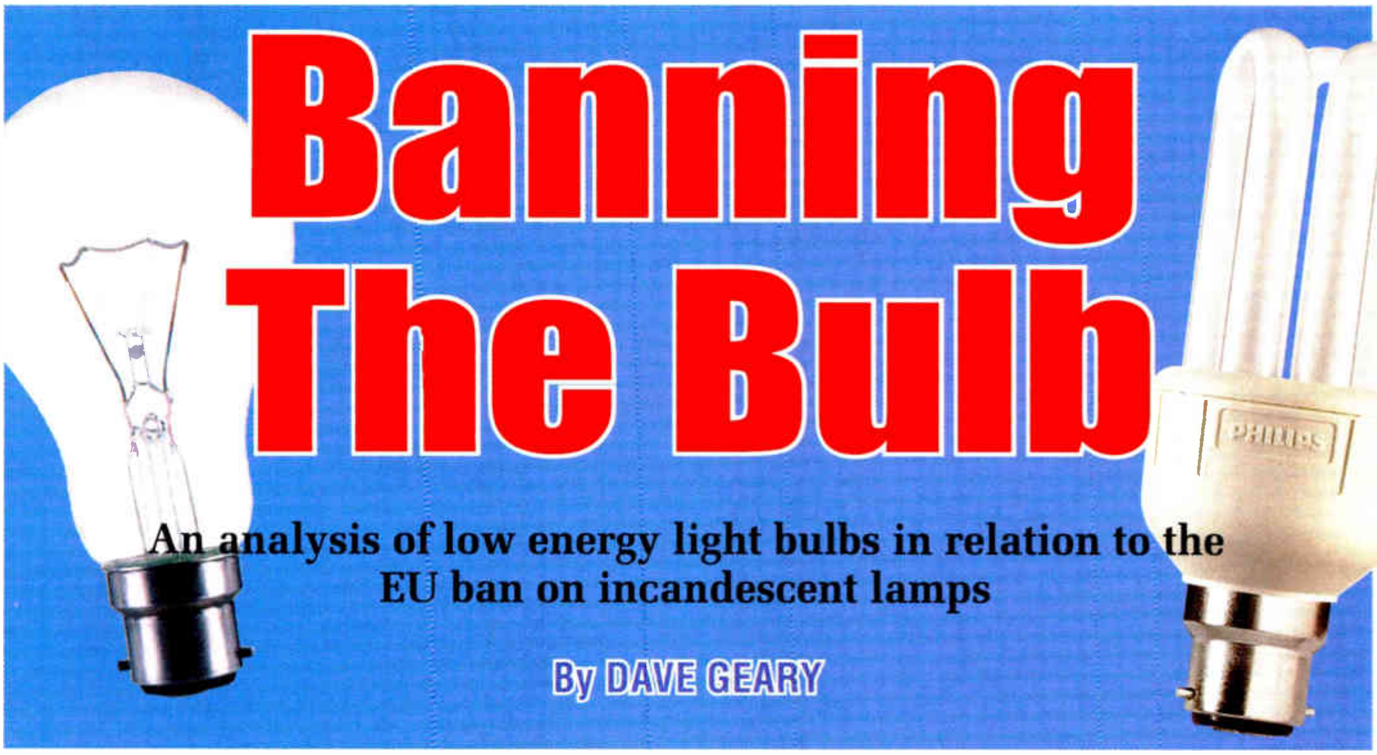
## Exclusive board offer

The Microchip PICDEM Mechatronics Development Board not only supports all of the projects featured in this series of articles but also includes nine example projects, each complete with source code.

To claim your exclusive *EPE* 20% discount on the Microchip PICDEM Mechatronics Development Board contact ACAL Semiconductors on Telephone: +44 (0)118 902 9702. Fax: +44 (0)118 902 9614. Email: sales@acalsemis.co.uk. Website: **www.acalsemis.co.uk**

## Links

**www.microchip.com/mechatronics**
**www.labcenter.com www. htsoft.com**
**www.epemag.co.uk**



# Banning The Bulb

## An analysis of low energy light bulbs in relation to the EU ban on incandescent lamps

By DAVE GEARY

THE *EPE Chat Zone* recently highlighted a potential move by the EU to ban incandescent lamps, including the humble domestic 'bulb'. In this article the author hopes to confirm what is true and dispel some myths, look at the potential impacts of this move and look at some of the solutions, including Compact Fluorescent Lamp (CFL), Tungsten Halogen (TH), and Light Emitting Diode (LED) technologies.

The author's background is over 20 years in the electrical wholesale distribution industry and he hopes you will forgive his use of the word 'lamp'. The 'trade' considers bulbs to be things that you plant! Lamps are sources of light, and they are installed in luminaires (or possibly, light fittings). The word 'bulb' is hereby banned!

### History of electric lamps

Firstly, some background. The General Lighting Service (GLS) lamp (Fig.1) was invented in the late nineteenth century, but right from the beginning was the subject of some controversy. There are two claims to be the original inventor and the lighting industry is still divided on just who is responsible for the massive effect artificial lighting has had on social and industrial development.

In the American corner, Thomas Edison (1847-1931) was an American inventor who achieved over 1000 patents. Although not the first to produce light from electricity, he designed a practical implementation which would become commercially viable.

Joseph Swan (1828-1914) was an Englishman who beat Edison to a practical design (1860) but was limited by the resources available to him at the time. Despite the now perceived rivalry, both inventors were eventually united in the Edison-Swan United Electric Light Company, and the brand of Ediswan lamps was born.

The operation of the GLS lamp has changed little but improvements have been made to extend the life and efficacy (light output for energy input) until the limit of the technology has been reached. Improvements have been made in the gas that replaces air inside the lamp and also the material used for filaments, from the bamboo supports used by Edison to tungsten steel used today.

Today, we see the same technology not just in the humble GLS lamp, but also in decorative versions of different colours, shapes and sizes. The candle lamp is the same technology but with a nicer shape, and all colours are produced by acid etched glass

**Fig.1. Philips GLS lamp**

**Fig.2. Philips Brilliantline low voltage dichroic**

Fig.3. Philips SON Sodium High Pressure Sodium Discharge

Fig.5. Philips HPLN Mercury Discharge

Fig.4. Philips SOX Sodium street lamp

or even just a painted coating. The tungsten halogen lamp, most easily recognised as low voltage spotlamps (Fig.2) in shops and kitchens, is one of the later developments which utilises clever chemistry to maximise life and light output, with some of the newest lamps using infrared filter/mirror technology to further enhance efficiency. Some of this technology will continue to be used for many years to come.

## Legislation and rumour

Commercial users have, of course, long since abandoned the old technology wherever possible to obtain the energy savings associated with discharge technology. This term includes all fluorescent lamps/tubes, compact fluorescent, sodium (Fig.3 and Fig.4), mercury (Fig.5) and metal halide lamps as used, for example, in streetlighting and shops. In addition, discharge lamps last longer and the cost of labour, including replacement access, which in some cases far outweighs the additional cost of these lamps and the necessary fittings.

Domestically, of course, there is no labour cost and generally it's easy to assume that the energy cost associated with lighting is small. However, with energy costs spiralling this is no longer the case, and with the costs of more energy efficient replacements coming down, the payback period is realistic.

The precise details of the proposed EU ban on incandescent lamps have yet to be disclosed. Even the Australian ban, which was announced some time ago, refers to 'less energy efficient incandescent lamps' and is not specific to type or wattage. However, various sources indicate that it is the higher wattage (40W to 100W) types used for general lighting which are targeted, and not those used for special applications (oven lamps, refrigerators, etc).

Many have assumed that the only allowable replacement will be compact fluorescent, but, in fact, other technologies, such as tungsten halogen (filament), are likely to be permissible as they are more efficient than GLS. They also maintain compatibility with dimmers and can be switched to full brightness immediately, so making

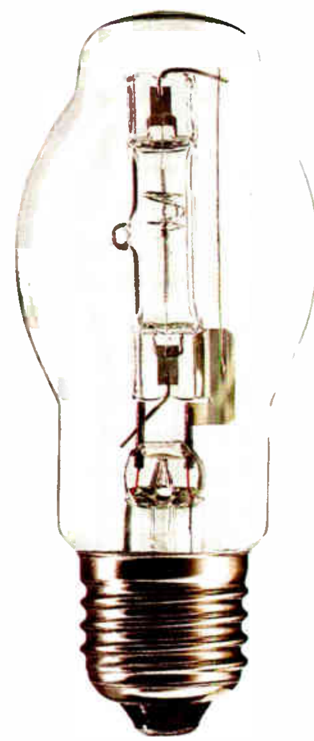


Fig.6. Philips HalogenA Discharge

**Table 1: Generalised Comparison**

| Type | CFL | TH |
|---|---|---|
| Runs | warm | hot |
| Hours | longest | better than GLS |
| Colour | to specification | 2700K (as GLS) |
| Starts | slowly-mod fast | instant |
| Appearance | OK-awful | 'bulb' (different shape) |
| Energy | best | med |
| Dimmable | no* | yes |
| Env Impact Mfr | higher | lower |
| Cost | med-high | med |

*some CFLs now have dimming capability, but not with traditional dimmers.

them suitable for security lighting. The key here is the measurement of efficiency/efficacy – lumens per watt (lm/W). The current Part L of the UK Building Regulations requires 40 lm/W.

Tungsten halogen lamps also have another key advantage – they are outside the scope of the WEEE directive (explained later) which will require yet more recycling segregation of rubbish in future years.

## Retrofit replacements

For most of us, there are two options; Compact Fluorescent (CFL) and Tungsten Halogen (TH). A quick and very generalised comparison is shown in Table 1.

## Tungsten halogen

Examples of the tungsten halogen option include the Philips HalogenA GLS replacement (Fig.6) and the Osram BT, which have been around for many years. Recently, there has been a dramatic expansion of the range to include other shapes and types of lamp. For example, the traditional reflector (or spot) lamp used in many kitchens and task lamps is now available in a lower energy TH version. Philips boast between 10% and 40% more light output, twice the life of the traditional lamp, and a 'whiter' light than the older technology. There are even replacements for decorative 'candle' lamps.

The difference between tungsten halogen and traditional GLS lamps is in the gas which fills the glass envelope, the filament, and the running temperature of the lamp. A GLS lamp uses the gas to delay the filament burning itself out, whereas tungsten halogen uses the gas to redeposit vapourised fragments of tungsten back onto the filament. This recycling extends the life of the lamp and provides additional stability to allow the filament to have a higher designed running temperature, which in turn increases light output in the visible spectrum.

As can be seen from the comparison table, tungsten halogen goes some way towards reducing energy consumption, and offers advantages of appearance, compatibility with dimmers, and lower environmental impact in manufacture. However, they do not achieve the extremely long life and low energy usage of CFLs. The author's understanding is that tungsten halogen lamps will not be the subject of the proposed ban since their efficiency is enhanced over GLS.


Fig.7. Philips SL lamp in latest guise

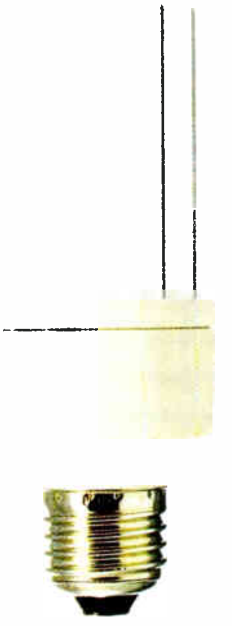


Fig.8. Philips Master PL-E

## Compact fluorescent

In general, lamps across the industry are specified on the following criteria:

a) Type or range, possibly manufacturer e.g. Philips HalogenA
b) Power, in watts
c) Cap, e.g. BC for Bayonet Cap
d) Colour, e.g. Clear/Pearl, or Cool White (fluorescent), sometimes by number such as 840 (explained later)

CFL retrofit lamps add two additional factors – life and light output per watt. These lamps first started life as the Philips SL range, which older readers might recall as a very heavy glass jar containing a folded fluorescent tube, a starter, and a wirewound choke.

They were excellent in many respects, but were relatively expensive for most of their product life. As a result, domestic use was limited but in the world of commercial buildings, the SL offered significant savings when the energy reduction was added to the long life and consequent labour saving due to not having to change lamps so often.

Their weight was also an issue, and the author has visited many clients over the years where SL lamps were installed hanging downwards, in downlighters, and towards the end of their life it was easy to pick out bits of brown resin that had fallen out of the choke and were laying on the inside of the glass jar! Of course, put them in a standard lamp, facing upwards ('base down' as the industry calls it), and the bayonet cap SL lamp would


Fig.9. Two new lamps from Megaman

Fig.10. Philips PL-E – note the loops against 'sticks' on this version

swing from side to side, pivoting on the pins on its base under its own weight! However, it would be wrong to underestimate the importance of this lamp, especially as it has only recently disappeared from sale, albeit with lighter, electronic gear installed (Fig.7).

Current lamps are much smaller, lighter, and more efficient (Fig.8 and Fig.9). Cost pressures, particularly with consumer demand, have forced the development of domestic and commercial grades. The consumer is making a decision on a handful of lamps around the home, and the energy saving effect is far lower. In addition, there are no labour costs to changing a lamp, just the nuisance factor. For these reasons, the lamp needs to have a lower price tag to make it an attractive proposition.

Manufacturers have responded to this by offering lower priced lamps with lower output and shorter life than the commercial ranges (Fig.10). It is not unusual to find a domestic lamp in the Superstore with a rated life of, say, 5000 hours, and a commercial grade lamp with between 15,000 and 20,000 hours. The cost difference is significant, with some supermarkets selling domestic lamps at under £1, with commercial lamps being typically between £5 and £10. This difference is insignificant if you have to pay someone to change a lamp three times instead of once.

## Light ouput

The lower light output may not be critical domestically but commercially it is very important, with standards for lighting in buildings requiring a given light output. If lower output lamps are installed, more fittings will be required and this negates any saving. Of course, the context of this article is retrofit lamps and it is unlikely that any commercial landlord would wish to add fittings to an existing installation, even if matching ones are available.

For the domestic market, while all of the major lamp manufacturers are producing an ever expanding product range, the most diverse is probably from Megaman. They are a fairly new entrant to the UK market and specialise in just retrofit lamps.

Commercial products tend to have a higher price tag but also higher output and longer life, which makes them an excellent prospect. In truth, these lamps are a better choice for the domestic market as well, but only to those who recognise the longer term benefits.

## Cost comparison

Philips have developed a clever Excel- based tool called 'Cost Of Ownership', which compares an existing lamp against a potential replacement, taking into account the price of the lamp, anticipated life, energy costs, and the labour cost each time a lamp is replaced. The latter is often a massive contributor to cost commercially, but since the scope of this text is typically domestic, it should be considered nil.

Other manufacturers operate similar methods of comparison, but of course the mathematics is fairly simple. To illustrate, let's take the example of a 60W GLS lamp used for four hours per day, seven days per week, replaced with an 11W compact fluorescent. Table 2 makes some assumptions about energy cost and the cost of a new lamp. It also shows a typical domestic CFL available from the supermarket and a typically more expensive commercial grade CFL. Pessimistic prices and lamp life have been assumed for the CFLs, so this is a worst case scenario.

**Table 2: Cost Comparisons**

| | 60w GLS | 11W CFL Domestic | 11W CFL Commercial |
|---|---|---|---|
| Hours per day | 4 | 4 | 4 |
| Hours per year (based on 365 days) | 1460 | 1460 | 1460 |
| *Cost of Buying Lamps* | | | |
| Lamp life | 1500 | 5000 | 15000 |
| No of lamp changes per year | 0.97 | 0.29 | 0.10 |
| Cost of new lamp | 0.20 | 3.00 | 7.00 |
| Cost of buying lamps per year | 0.19 | 0.88 | 0.68 |
| *Cost of Running Lamps* | | | |
| Lamp power (W) | 60 | 11 | 11 |
| Electricity cost £/kWh | 0.09 | 0.09 | 0.09 |
| Cost of running lamps per year | 7.88 | 1.45 | 1.45 |
| *Cost of Buying and Running* | 8.08 | 2.32 | 2.13 |

It is evident from the table that the commercial grade CFL is actually far better value than the GLS lamp it replaces, even though it costs 35 times as much.

## Carbon footprint

Notwithstanding the obvious financial benefits of CFL, there are impacts on the environment associated with lighting. Philips state that 19% of all energy consumption worldwide is lighting related (a figure attributed to the International Energy Agency). The energy saving aspects of CFLs are, therefore, unarguable.

If recycled, the environmental impact of moving CFLs from factory to eventual user and then to recycling facility is mitigated by the number of new lamps being reduced (i.e. fewer changes means less movement of goods).

Any use of energy has an environmental impact. Osram have provided a technical data sheet which uses a comparison between the overall impact of 15 GLS lamps against one of their commercial grade replacements.

The 15 incandescent lamps will use some 12.9kWh in their manufacture, and 1125kWh in energy during operation. This totals 1137.9kWh. The CFL replacement uses only 3.4kWh in manufacture, 225kWh during operation, totalling 228.4kWh. This represents, according to the datasheet, a saving of 909.5kg of carbon dioxide emissions.

The mercury within the lamp is mitigated by the mercury which is not emitted during the burning of fossil fuels to produce the extra energy. An Osram CFL uses mercury (as all must to operate), but this has been reduced through design to 3mg per lamp.

## Disposal – WEEE Directive

However, these lamps also use a cocktail of artificial substances in their construction, including mercury and phosphorous, and as a result are included in the WEEE Directive (Waste Electrical and Electronic Equipment) requiring the recycling of these lamps for commercial users. Domestic users will be advised and requested to recycle, possibly via the retailer from which they were purchased.

Later in 2007, it is highly likely that prices of CFLs will have to rise to cover their eventual recycling/disposal, although this will not be sufficient to remove the huge running cost advantage over GLS.

The WEEE Directive covers, within lighting:

- Luminaires for fluorescent lamps with the exception of luminaires in households
- Straight fluorescent lamps
- Compact fluorescent lamps
- High intensity discharge lamps, including pressure sodium lamps and metal halide lamps
- Low pressure sodium lamps
- Other lighting or equipment for the purpose of spreading or controlling light with the exception of filament bulbs

Source: **www.weeedirectory.com**

All items within the scope of the WEEE Directive must be recycled, including such items as refrigerators and televisions. Since these items are fairly expensive, the added surcharge for recycling is insignificant and is generally being absorbed by the manufacturer. In the case of lamps, the unit price is far lower and recycling costs are more significant. At the time of writing, there is still some debate within the industry as to whether prices will simply rise to cover it or, commercially at least, there will be a separate environmental disposal charge on CFLs and some other lamps, as is currently the case with tyres.

GLS lamps are not affected since their construction is of inert materials. There is an expectation of a 'WEEE charge' of around 30p per lamp or an increase in the price of the lamp of similar proportions.

A new organisation, Recolight, is responsible for collecting these charges and administering payments to recycling companies, see **www.recolight.co.uk**.

Households are under no obligation to recycle under the WEEE Directive, although it is encouraged, and could be required under local bylaws.

To quote **www.weeedirectory.com**:

*Consumers and the WEEE Directive – Household:*

*As a private household you are under no obligations to recycle WEEE, but, you will receive information encouraging you to recycle WEEE.*

The precise link is **www.weeedirectory.com/Default.aspx?tabid=95**

## Control gear – lamp electronics

One potential concern with retrofit CFLs is that the fittings may not have adequate ventilation or other methods of cooling. The fitting is not likely to suffer any ill effects, since the running temperature of any incandescent lamp is far greater than the fluorescent replacement.

Osram point out that all electronic ballasts are sensitive to ambient temperature, although so long as this is below around 70°C, then the normal life of the gear will be achieved, i.e. life of the overall lamp will be unaffected. Over 70°C, and life reduces exponentially, so this may be an issue in certain installations.

Philips do not believe that life will be adversely affected, provided that the CFL used is of an equivalent to the GLS replaced.

Another issue which touches on control gear is the warm-up time. Modern replacement lamps from the leading manufacturers reach full output within less then 30 seconds, and this depends again on ambient temperature; the colder the room, the dimmer the lamp will be initially. However, Osram state that their electrodeless technology, as used on the Dulux EL Longlife Classic A 20W, comes on instantly at around 90% output, then rising to 100%.

The Lighting Association requires that, in normal operation, all CFLs should reach at least 60% brightness in 60 seconds, and the major brands discussed here would appear to easily meet that criterion. They go on to recommend that consumers should only purchase lamps which bear the logo 'Energy Saving Recommended' and avoid cheap, poor quality lamps.

Most older designs of CFL retrofit lamps use an electronic version of the conventional inductive starter circuit. However, the electrodeless Osram lamps, and other newer designs, use a high frequency (30kHz to 50kHz) control gear which further enhances efficiency and eliminates visible flicker, together with stroboscopic effects.

Over recent years, the overall lamp (including control gear) size for any given wattage has significantly reduced, together with control gear losses, and the mercury content of the lamps. Conversely, average lifetimes have increased.

The author sought clarity on the question of power factor from Philips: 'The stated wattage on the lamp includes the effect of the inherent power factor and does not further influence energy savings.' They go on to make another valid point: 'The marked reduction of current with CFL lamps also reduces the distribution losses in the supply system'.

## Special uses and alternative approaches

Retrofit lamps have traditionally been viewed as uncontrollable, other than 'on' and 'off'. However, the Osram range now incorporates extra facilities, such as photocell control (to allow for automatic simulation of 'at home' lighting, Dulux EL-SENSOR), dimming via conventional dimmers (Osram EL-DIM), or dimming with a switch on the case of the EL-VARIO.

So far, this text has concentrated on retrofit solutions, where the luminaire (fitting) is already installed and there is no desire to change it. The best solution, of course, is a fitting which is designed to use a more energy efficient light source and, if fluorescent, incorporates the required control gear in the fitting.

This also has the advantage of offering high frequency gear, which operates the lamp at around 32kHz, eliminating all traces of flicker, all stroboscopic effects and reducing energy consumption by, typically, a further 5% to 10%. Thorn Lighting are one of many manufacturers offering such luminaries, and while much of their range is commercially focussed, a trawl on *Google* will find many companies offering excellent energy saving fittings which are also attractive.

LED technology is still in its relative infancy and is yet to offer a viable alternative for key reasons: first, the light output is not yet sufficiently high, and second, the light output of an LED degrades over time too much to allow the meeting of minimum light level requirements to be guaranteed for enough of the product life. Osram and Philips both contend these issues will be solved in the near future.

By way of comparison, efficiencies, irrespective of colour appearance of the lamp and the aesthetics of the lamp, are shown in Table 3 for typical Philips versions.

**The author has made a contribution to an industry charity – The Electrical and Electronic Industries Benevolent Association (www.eeiba.org) – in recognition of the support received from lamp manufacturers in the preparation of this article.**

The key factors are always energy efficiency and acceptability of aesthetics. Hopefully, this article has provided some thought-provoking information – hard fact – to counter the rumours that CFLs are either 'all good' or 'all bad'. The author has used them very successfully, but only where appropriate. Have a look on the manufacturers' websites, there are lots of new products arriving to meet the challenges – these are exciting times! ***EPE***

**Table 3: Typical Lamp Efficiences**

| Lamp | lm/W | Life |
|---|---|---|
| GLS | 10-15 | 1000 hrs |
| TH (Philips BTT HalogenA) | 14-17 | 2000 hrs |
| CFL (Philips Master PL electronic) | 46-68 | 15000 hrs (70% output) |
| LED | <45 | 35000 hrs (70% output) |

### Acknowledgements and References


Megaman (UK) Limited – **www.megamanuk.com**

Philips Lighting Limited – **www.lighting.philips.com**

Osram Limited – **www.osram.co.uk**

Ban The Bulb – **www.banthebulb.org**

Energy Saving Trust – **www.energysavingtrust.org.uk**

Recolight – **www.recolight.co.uk**

WEEE Directory – **www.weeedirectory.com**

Thorn Lighting – **www.thornlight.com**

The Lighting Association – **www.lightingassociation.com**

Regular Clinic

# Circuit Surgery

## Ian Bell

## Regulator stability and switch bounce

User *Gerry* posted a question on the *EPE Chat Zone* (via **www.epemag.co.uk**) concerning the recent *Circuit Surgery* articles on regulator stability.

*I've been following the recent* Circuit Surgery *articles. Although I understood them, I was wondering what are the symptoms of an 'unstable' regulator?*

*I appreciate that it'll oscillate, but if it's at such a high frequency surely this wouldn't show up on a multimeter? Or do regulators simply not work when they oscillate? I've been using regulators for years and, to my knowledge, have never had this problem, but these articles have me curious now!*

Gerry is correct that the key symptom of instability is (by definition) oscillation, but unfortunately it is not possible to give a simple general description of the impact this will have because there is a wide range of possibilities. The oscillation will vary in both frequency and amplitude depending on the type of regulator and the impedance of the supply. It is also likely to be temperature sensitive.

As was noted in the previous articles, it is LDO (low dropout) regulators that are particularly susceptible to instability, not standard regulators. Also, if the instructions on the datasheet are followed and the correct types and values of capacitors are used, there should not be any problems. If this applies to Gerry then it is not surprising that he has never experienced problems.

### Non-functional?

It is possible that the regulator's output will be so far from what it should be that the circuit would be considered non-functional. Although this might be annoying, at its least, it is easy to detect and diagnose. However, an unstable regulator may also oscillate at a low amplitude while maintaining more or less the correct DC level. You may need to look at the supply with an oscilloscope to see this.

An application note from Analog Devices/Analog Integrations Corporation (AIC) titled *Analysis of LDO oscillation issues* (AN025) (see **www.analog.com.tw/DB/doc/app_note/an025.pdf**) gives an example waveform for an AIC1730-33 3.3V low-noise 150mA LDO regulator suffering instability. The amplitude of the oscillation is around 400mV and the frequency is about 170kHz, but remember this is just an example and other unstable regulators will behave differently. For those interested in the mathematical analysis of stability (which we only skimmed over in the *Circuit Surgery* articles) the same application note also provides a pole-zero analysis of an LDO regulator equivalent circuit.

The impact of an LDO oscillating in this way will depend on the nature of the circuit being powered by it. In effect, the oscillations create a high level of power supply noise. As LDO regulators are typically used instead of switching circuits in low noise applications this is quite likely to be a serious problem.

If the oscillation frequency of the regulator is within the range of frequencies processed by the circuit then it is likely that it will be manifested as a strong noise signal in the circuit's output. However, if the oscillation is well outside the circuit's range, it may not be so obvious. This does not mean all is well of course, as there may be other undesirable effects such as increased electromagnetic emissions from the circuit board causing interference elsewhere.

*Zeitghost*, responding to Gerry's post on the forum, provides an interesting example of a circuit that was apparently OK, but, in fact, was not functioning exactly as it should be due to regulator instability.

*I remember a regulator based on the 7663 that oscillated gently at about 20kHz. This didn't matter until the power control for a UHF transmitter changed from being ground referenced to being +5V referenced. It went totally unnoticed until one day I increased the span on a spectrum analyzer and found two sidebands at +/– 20kHz re the carrier.*

### Bouncing switches

The problem of switch bounce has also been discussed on the *EPE Chat Zone* recently. This is an issue which has frequently confused beginners over the years.

Typically, someone connects a mechanical switch as an input to a logic circuit, presses the switch once and finds the circuit behaving as if the switch has been pressed two or three times. If you don't know that switch contacts bounce, causing the switch to go on and off a few times before it settles, then this can be quite a perplexing problem.

At first, people suffered from this problem with discrete logic circuits built from 4000 or 74 series or similar devices, but now PIC and other microcontroller-based projects also need to take account of switch bounce. For discrete logic, the problem is often particularly acute if the switch is connected to a clock or other 'edge-triggered' logic input.

### Capacitor cure?

*Chat Zone* user ***Tuurbo46*** is aware of the need to debounce switches in his PIC application, but was asking for advice on getting it just right.

*I'm currently having a little problem with debouncing a switch. When the switch is pressed, the non-polarised capacitor debounces the switch ok, and the I/O pin goes high. But my problem is the stored voltage in the capacitor holding the I/O pin high for ages. I'm currently using a 100nF capacitor. Should I make the value of my capacitor smaller, or should I use a polarised capacitor or discharge the capacitor?*

Fig.1 shows a simple switch and pull-up resistor arrangement, which could be used as the input to a logic circuit, or connected to a microcontroller digital I/O pin configured for an input. A possible waveform for the circuit's output is also shown in Fig.1. Here we see the switch bouncing

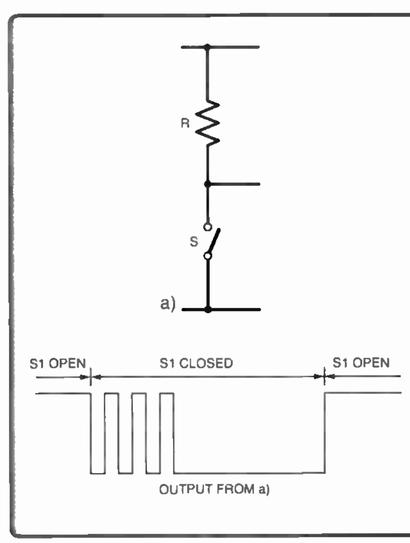



*Fig.1. Bouncing switch*

three times as the contact is closed, but not as it is opened.

This is not the only possible behaviour – different switches bounce different amounts and at different switch positions. The number of bounces often varies each time an individual switch is used. The duration of bouncing also varies with switch type, but is typically in the range of hundreds of microseconds up to 10ms to 20ms (although even longer bounce times do occur).

The way in which the user actuates the switch – hard/soft fast/slow movement – will also affect bouncing behaviour. A further complication is that during bouncing, the voltage transitions may not cover the full supply range and may therefore take logic inputs into their undefined region (between 0 and 1).

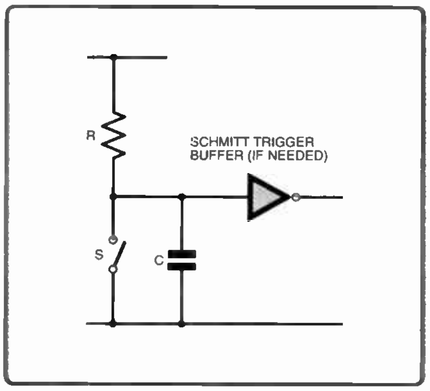



*Fig.2. Using a capacitor to debounce a switch*

One of the simplest approaches to debouncing is to use a capacitor as shown in Fig.2. This is the arrangement Tuurbo46 is referring to. The *RC* time constant should be a little more than the switch bounce time. If it is much greater, then the response of the debouncing switch may be too slow, and the system may be perceived as sluggish by the user.

The slowly rising input signal produced by the circuit in Fig.2 may be a problem for some logic families, and particularly noisy environments may even cause a similar problem to bouncing as noise pushes the input over the logic threshold and back again. This may produce even more unwanted transitions than the original switch bounce. If it is a problem, a Schmitt trigger device can be inserted between the switch and the logic input to produce clean logic switching (as shown in Fig.2).

Another potential problem with the circuit in Fig.2 is when high currents flow in the switch when it is closed. If a relatively large value of capacitor is used, this may degrade the switch over time.

Furthermore, when *S* is closed, *R* is connected across the supply and will consume power, so *R* should be as large as possible to minimise this. So it is best to use a relative large resistor value and a relatively small capacitor value for the *RC* value required, taking into account the maximum resistor value that will provide a reliable pull-up with the logic technology used.

## Additional resistor

A resistor can be placed in series with the capacitor to limit the current as shown in Fig.3, in which case a diode may also

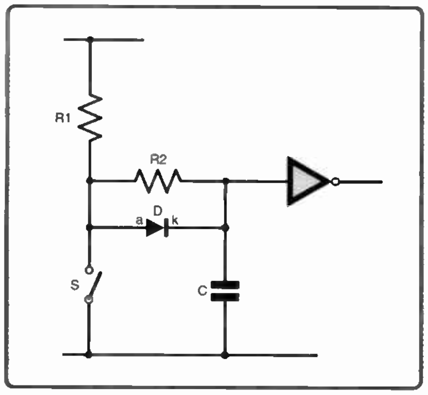



*Fig.3. Improved debounce circuit*

be required (as shown). If the diode is not present then both R1 and R2 set the *RC* time constant when the switch is open.

This results in a slower circuit than if just R1 is used. Resistor R1 could be made smaller but this increases the current taken when the switch is closed. A potential problem with this circuit is that logic input leakage current dropped across the resistor may degrade the logic levels.

All this means that the choice of component values for this circuit may be tricky at times, although it should always be possible to get it to work.

An RS flip-flop can also be used to debounce a switch as shown in Fig.4. This requires a changeover switch and two pull-up resistors, but does not require any setting of time constants, and does not suffer from problems with slowly changing inputs.

When the switch changes, any bouncing will simply set or reset the flip-flop multiple times, but this does not matter as only the first set or reset changes the state of the flip-flop. Note that individual switch contacts bounce open and closed, but the switch does not bounce all the way between the two contacts, otherwise this circuit would not work.

## Other techniques

When using a microcontroller, switches can be debounced using software. Typically, the code detects a change on the switch and then waits for a bounce delay before checking the switch's state again and acting on the switch press if the state has actually changed.

The code is simple and examples are readily available, but it can be more difficult to do software debounce if a large number of switches are required. In such cases, hardware debouncing using a debounce IC may be preferable.

There are special switch debouncing ICs available, for example from Maxim **www.maxim-ic.com**). The MAX6816, MAX6817 and MAX6818 are single, dual, and octal switch debouncers,

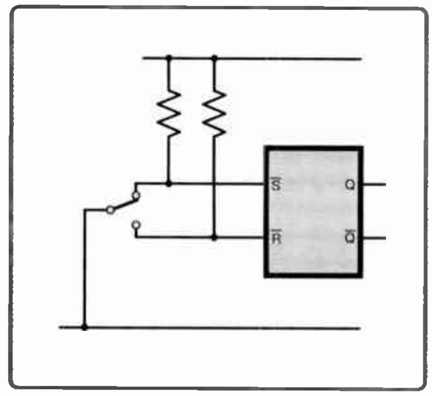



*Fig.4. Switch debounce using an RS flip-flop*

respectively. The switch inputs on the these devices have overvoltage clamping diodes to protect against damaging fault conditions and switch input voltages can safely swing to ±25V with respect to ground. A typical circuit using the MAX6816 single switch debouncer is shown in Fig.5.

The MAX6818 monitors eight switches and provides a switch change-of-state output, which indicates if any of the switches have changed state. This simplifies interfacing to a microcontroller, which does not have to do the work of checking to see if each of the individual switches have changed. A typical circuit using the MAX6818 is shown in Fig.6.

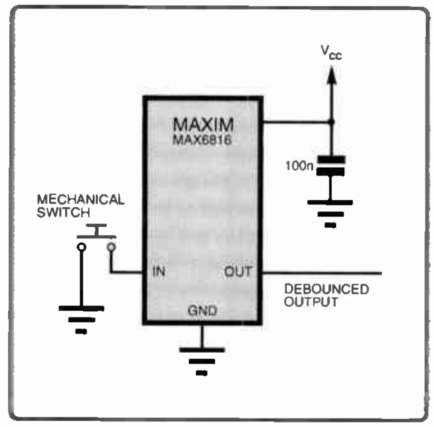



*Fig.5. Switch debounce using a MAX 6816 (Maxim datasheet)*

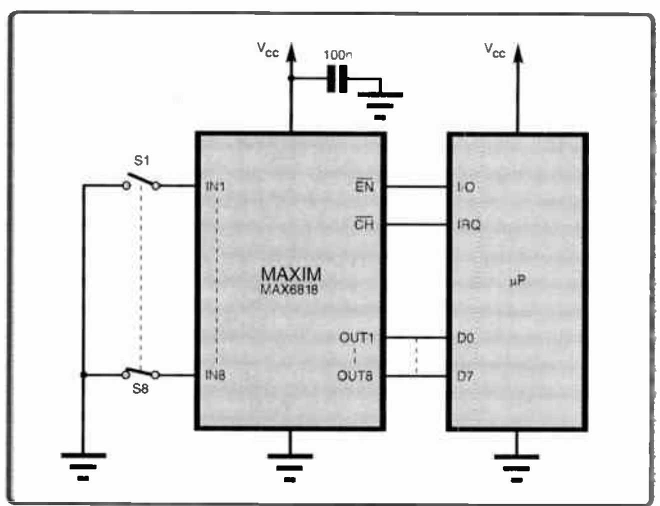



*Fig.6. Multiple switch debounce using a MAX6818 (Maxim datasheet)*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# ELECTRONICS CD-ROMS

## ELECTRONICS PROJECTS

Logic Probe testing

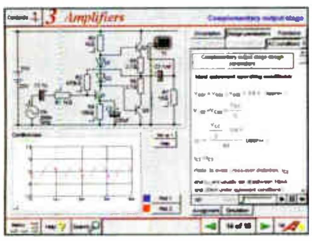
*Electronic Projects* is split into two main sections: **Building Electronic Projects** contains comprehensive information about the components, tools and techniques used in developing projects from initial concept through to final circuit board production. Extensive use is made of video presentations showing soldering and construction techniques. The second section contains a set of ten projects for students to build, ranging from simple sensor circuits through to power amplifiers. A shareware version of Matrix's CADPACK **schematic capture, circuit simulation** and **p.c.b. design** software is included.
The projects on the CD-ROM are: Logic Probe; Light, Heat and Moisture Sensor; NE555 Timer; Egg Timer; Dice Machine; Bike Alarm; Stereo Mixer; Power Amplifier; Sound Activated Switch; Reaction Tester. Full parts lists, schematics and p.c.b. layouts are included on the CD-ROM.

## ELECTRONIC CIRCUITS & COMPONENTS V2.0

Circuit simulation screen

Provides an introduction to the principles and application of the most common types of electronic components and shows how they are used to form complete circuits. The virtual laboratories, worked examples and pre-designed circuits allow students to learn, experiment and check their understanding. Version 2 has been considerably expanded in almost every area following a review of major syllabuses (GCSE, GNVQ, A level and HNC). It also contains both European and American circuit symbols. Sections include: ***Fundamentals:*** units & multiples, electricity, electric circuits, alternating circuits. ***Passive Components:*** resistors, capacitors, inductors, transformers. ***Semiconductors:*** diodes, transistors, op.amps, logic gates. ***Passive Circuits. Active Circuits. The Parts Gallery*** will help students to recognise common electronic components and their corresponding symbols in circuit diagrams. Included in the Institutional Versions are multiple choice questions, exam style questions, fault finding virtual laboratories and investigations/worksheets.

## ANALOGUE ELECTRONICS



Complimentary output stage

*Analogue Electronics* is a complete learning resource for this most difficult branch of electronics. The CD-ROM includes a host of virtual laboratories, animations, diagrams, photographs and text as well as a SPICE electronic circuit simulator with over 50 pre-designed circuits.
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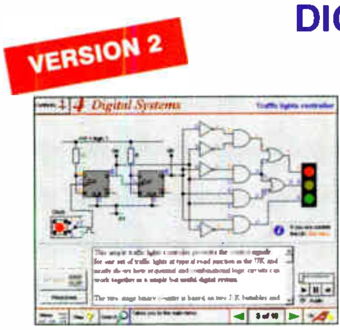
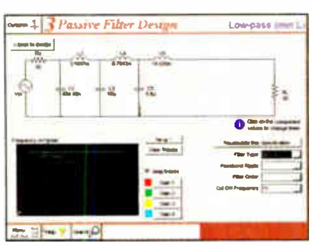
## DIGITAL ELECTRONICS V2.0



Virtual laboratory – Traffic Lights

*Digital Electronics* builds on the knowledge of logic gates covered in *Electronic Circuits & Components* (opposite), and takes users through the subject of digital electronics up to the operation and architecture of microprocessors. The virtual laboratories allow users to operate many circuits on screen.
Covers binary and hexadecimal numbering systems, ASCII, basic logic gates, monostable action and circuits, and bistables – including JK and D-type flip-flops. Multiple gate circuits, equivalent logic functions and specialised logic functions. Introduces sequential logic including clocks and clock circuitry, counters, binary coded decimal and shift registers. A/D and D/A converters, traffic light controllers, memories and microprocessors – architecture, bus systems and their arithmetic logic units. Sections on Boolean Logic and Venn diagrams, displays and chip types have been expanded in Version 2 and new sections include shift registers, digital fault finding, programmable logic controllers, and microcontrollers and microprocessors. The Institutional versions now also include several types of assessment for supervisors, including worksheets, multiple choice tests, fault finding exercises and examination questions.

## ANALOGUE FILTERS



Filter synthesis

*Analogue Filters* is a complete course in designing active and passive filters that makes use of highly interactive virtual laboratories and simulations to explain how filters are designed. It is split into five chapters: **Revision** which provides underpinning knowledge required for those who need to design filters. **Filter Basics** which is a course in terminology and filter characterization, important classes of filter, filter order, filter impedance and impedance matching, and effects of different filter types. **Advanced Theory** which covers the use of filter tables, mathematics behind filter design, and an explanation of the design of active filters. **Passive Filter Design** which includes an expert system and filter synthesis tool for the design of low-pass, high-pass, band-pass, and band-stop Bessel, Butterworth and Chebyshev ladder filters. **Active Filter Design** which includes an expert system and filter synthesis tool for the design of low-pass, high-pass, band-pass, and band-stop Bessel, Butterworth and Chebyshev op.amp filters.

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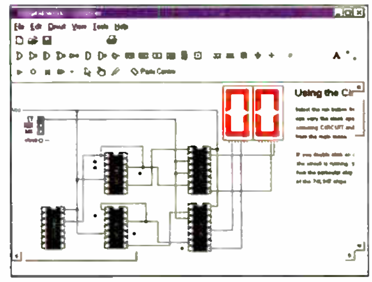

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- Interactive Virtual Laboratories
- Little previous knowledge required
- Mathematics is kept to a minimum and all calculations are explained
- Clear circuit simulations

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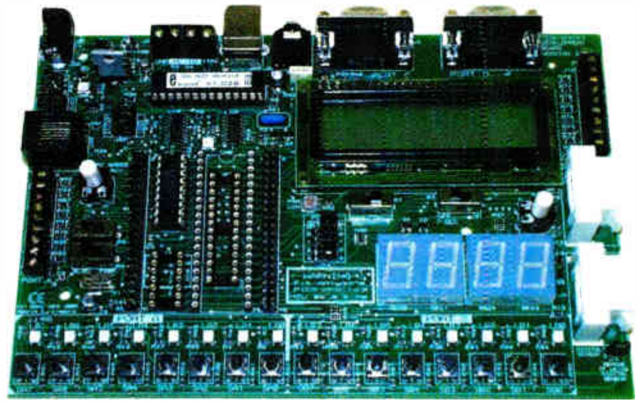

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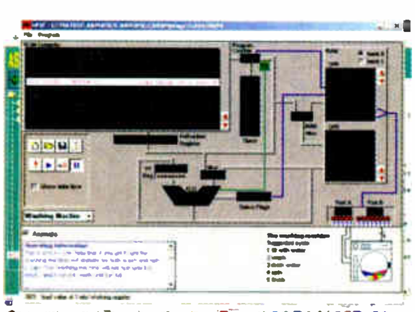

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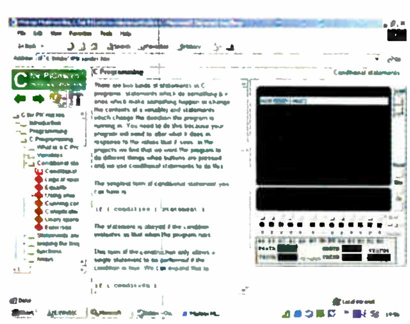

Minimum system requirements for these items: Pentium PC running Windows 98, NT, 2000, ME, XP; CD-ROM drive; 64MB RAM; 10MB hard disk space.

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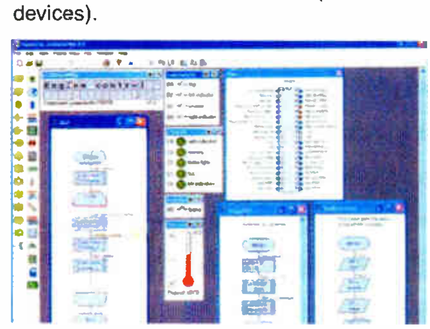
Flowcode produces MPASM code which is compatible with virtually all PICmicro programmers. When used in conjunction with the Version 3 development board this provides a seamless solution that allows you to program chips in minutes.

● Requires no programming experience ● Allows complex PICmicro applications to be designed quickly ● Uses international standard flow chart symbols ● Full on-screen simulation allows debugging and speeds up the development process.

● Facilitates learning via a full suite of demonstration tutorials ● Produces ASM code for a range of 18, 28 and 40-pin devices ● New features in Version 3 include 16-bit arithmetic, strings and string manipulation, improved graphical user interface and printing, support for 18 series devices, pulse width modulation, I2C, new ADC component etc. The Hobbyist/Student version is limited to 4K of code (8K on 18F devices).



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# Standby Power Saver

Play your part in reducing energy use at home

By JOHN BECKER


Readers will be aware that internationally active measures are being taken to conserve energy. One such source of energy consumption is from TVs and other domestic items being left in Standby mode. It is perhaps human nature that most of us use this option, prefering the more instantaneous revitalising of the TV rather than turning it off when not needed, and then having to wait while it warms up again. It also saves getting up out of the chair to physically switch it off!

PCs are other culprits that are left in standby rather than being turned off. The reason here is more fundamental. A procedure has to be entered each time we wish to turn off a PC, and there is the fairly lengthy time that it takes to reboot back into working mode.

There are other household appliances that have a standby option as well.

The unit presented here offers an answer to the standby problem of TVs and other devices, but not to that associated with PCs.

## Handset options

Basically the design consists of two units, one handheld, the other mains powered and connected to the TV or other appliance between its normal plug and the mains socket. Communication between the units is by radio frequency (RF) at the UK legal frequency of 433MHz, using ready-made and readily available transmitter/receiver modules. This means that a radio transmitting license is not required in the UK.

At its basic level, the system comprises one transmitting module controlling a single receiving unit. It is possible, though, to use a single controller to control up to 64 receiving modules, jointly or independently.

This possibility allows households with more than one TV etc (but not PCs, as mentioned) to be all controlled by the same transmitter. The range is up to about 70 metres, so will penetrate through the rooms and ceilings of most houses. The main unit can thus be kept in one room and appliances in other rooms controlled from the same place.

Each controlled unit is allocated an independent ID code, between 0 and 63, set by the user with link wires on the PCB (printed circuit board), or using switches. The controller then, by means of switches, selects the ID code of the unit it wishes to control.

Receiver units also have an independent push-switch allowing the transmitted setting to be over-ridden and the unit turned on and off directly.

Appliances have their mains power switched on and off by means of a relay in the receiving unit. The receiving unit is plugged into the mains supply, and the appliance then plugged into the receiver. The relay is basically designed to switch up to 5A AC, but it may be changed to another capable of switching greater currents.

**It is stressed that the assembly of the mains aspect of the receivers must only be done by someone suitably competant at doing so. Mains electricity is potentially hazardous and can kill.**

## Transmitter

The complete circuit diagram for the transmitting (Tx) unit is shown in Fig.1. It is under control of PIC microcontroller IC1. At any time the mode under which it operates is set by S2 to S4. The individual ID code that it transmits is set by the bank of six DIL switches jointly labelled S5.

To control a single receiving unit, Apparatus On or Off switch S4 is switched appropriately, and S2, the Named Unit switch, is pressed.

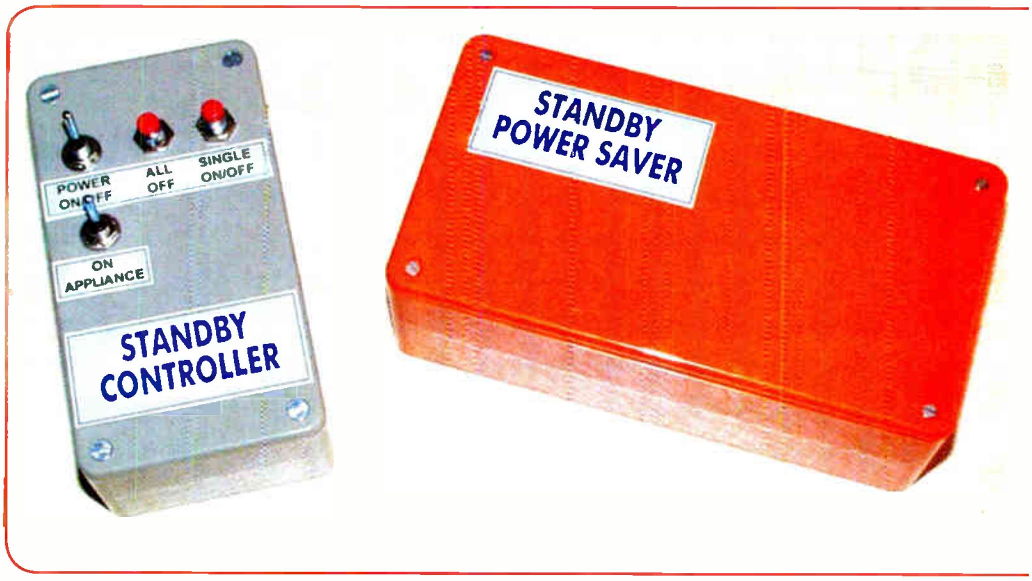
The PIC sends a basic general ID code first. This minimises the risk that other transmitters in the neighbourhood operating on the same 433MHz frequency will interfere. This ID code may be selected by the user to be any value between 64 and 127 (more on this later).

The PIC then sends the ID of the unit to be controlled, a user selected value between 0 and 63. To this value is added the status of switch S4, zero for Turn Power Off, or 128 for Turn Power On.

The PIC's signals are sent to the transmitter module, IC2, an RF Solutions type AM-TX1-433 (also available from RS Components Ltd as stock number 310-9891). Data transfer rate is at 4800 Baud.

On receipt of both ID codes, the desired receiver unit then performs the task required.

To control all possible 64 units simultaneously, switch S3 is pressed




**The completed prototype transmitter (left) and receiver (right) modules that make up the Standby Fower System. Not shown on the receiver unit are the Main ID and Unit On/Off pushbutton switches (S6 and S7)**

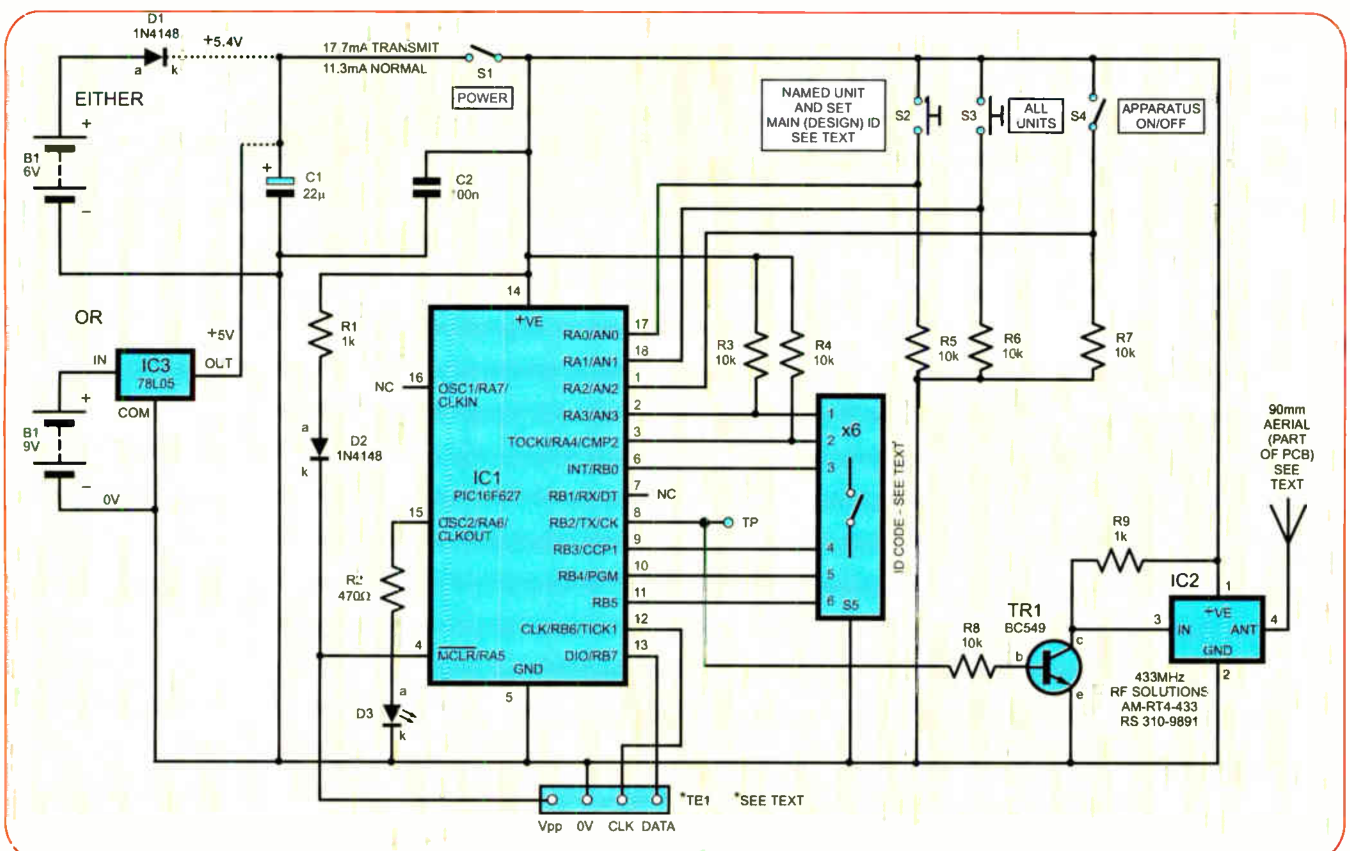



**Fig.1. Circuit diagram for the Standby Power Saver transmitter. There are two power supply options – see text**

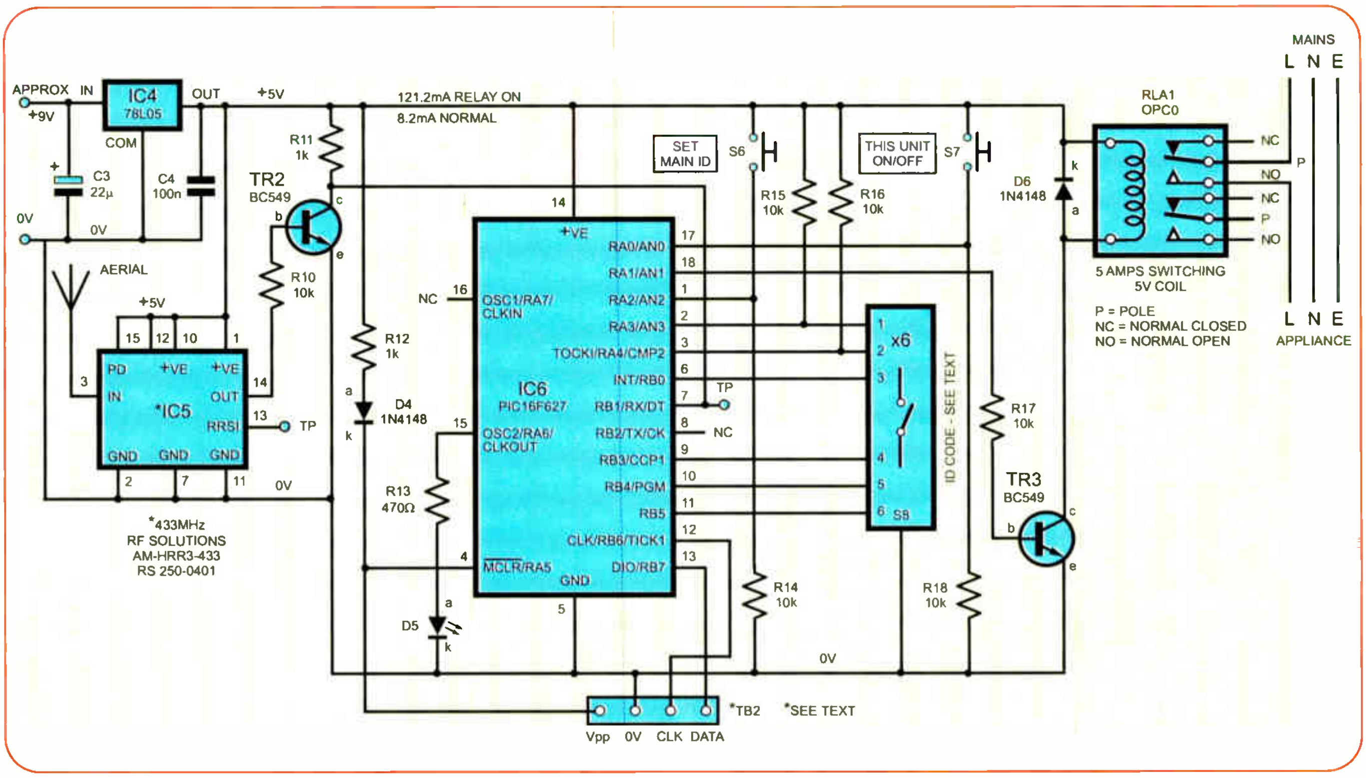



**Fig.2. Circuit diagram for the remote receiver section of the Standby Power Saver**

and again the PIC sends a main ID code and a unit ID which commences at 0 and increments up to 63. Any unit which receives the main ID and its individual ID code, again performs the task required.

LED D3 is turned on during transmission, and turned off again at the end, so the user knows when the process is complete. Even when sending all 64 codes, the cycle time is only about one second.

## Receiver

The circuit diagram for the receiving (Rx) unit is shown in Fig.2. The circuit comprises receiver module IC5, an RF Solutions type AM-HRR3-433 (also available from RS Components Ltd as stock number 250-401), PIC microcontroller IC6, and a few peripheral components, including the 5A AC relay, RLA1.

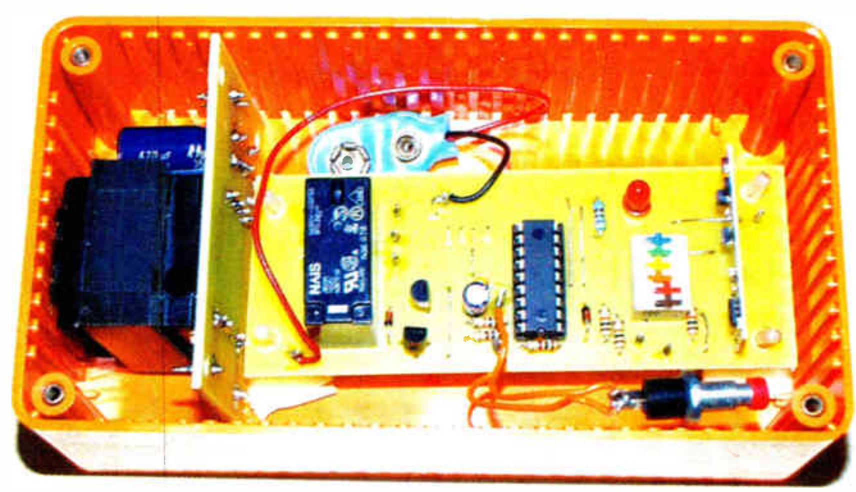
The receiver sends any received codes to the PIC, which assesses whether or not they have the appropriate main and individual unit IDs. Both of these are determined by the bank of six switches, or link wires, S8 (more on this later). If the codes are valid, the PIC then switches transistor TR3, and thus the relay, on or off as required. Diode D6 inhibits any back-EMF pulse generated at the moment the relay is switched off.

The relay is a PCB-mounted two-pole changeover type rated for switching up to 5A. Both Live and Neutral appliance lines may be jointly switched as required. LED D5 is turned on when the relay is switched on.

Switch S7 allows the relay to be manually switched on or off as required. Switch bank S8 is used when the receiver's ID is to be set by S6.

## Both units

The PICs operate at 4MHz, as set by their own internal oscillator. Communication between transmitter and receiver is at 4800 Baud. Both PIC units are powered at +5V, derived from a basic 9V supply, which is regulated down to +5V by regulators IC3 (Tx) and IC4 (Rx).



**Layout of components, including optional mains power supply, inside a partially completed receiver unit**

With the Tx unit, it is intended that a PP9 9V battery is used, although a 6V battery could be used instead. In this latter case diode D1 reduces that voltage to below the maximum allowed for the PIC (5.5V) and regulator IC3 is then omitted.

For the Rx unit, the power may be supplied by a PP3 9V battery, or via the simple PSU shown in Fig.3.

Connector blocks TB1 and TB2 allow the PICs to be programmed when installed on the PCBs if preferred. The pins are in the author's usual configuration. The software is available from the 'Downloads' section of the *EPE* website.

## Rx PSU

The circuit diagram for the simple 9V DC power supply (PSU) is shown in Fig.3. It is intended that the same mains supply as is controlled for the appliance should be used.

Transformer T1 steps down the mains voltage (230V AC in the UK) to 6.3V AC. This is rectified by REC1, smoothed by capacitors C1 and C2, from which approximately 9V DC is available for the Rx unit.

## Assembly

There are three printed circuit boards (PCBs) for this design. They are available from the *EPE PCB Service*, codes 639 (Tx), 640 (Rx), 641 (PSU). Only one Tx PCB is needed. For the Rx units, an Rx PCB is needed for each controlled appliance, plus a PSU PCB if required.

The circuit board assemblies and full-size copper tracking details are shown in Fig.4, Fig.5 and Fig.6. As said earlier, the mains aspects of this design must only be assembled by those who are competent to do so.

Assemble the PCBs in order of component assembly size, starting with the on-board wire links. Use sockets for the dual-in-line (DIL) ICs, and observe the correct polarity for all electrolytic capacitors and semiconductors. Do not

## Parts List – Standby Power Saver

### TRANSMITTER

1 PC board, code 639 (Trans) available from the *EPE PCB Service*, size 96mm × 38mm
1 plastic case, size and type to individual choice
1 433MHz AM radio transmitter module, type AM-RT4-433 (RF Solutions) (IC2)
2 miniature SPST toggle switches (S1, S4)
2 miniature push-to-make SP pushbutton switches (S2, S3)
1 6-way DIL switch or six SPST toggle switches – see text (S5)
1 12-pin DIL socket – see text
1 18-pin DIL socket
Multistrand connecting wire; battery to suit – see text; solder etc.

**Semiconductors**
2 1N4148 signal diodes (D1, D2)
1 3mm red LED (D3)
1 BC549 *NPN* transistor, or similar small-signal type (TR1)
1 PIC16F627-4 preprogrammed microcontroller (IC1). (Ready-programmed PICs are available from Magenta Electronics – see their advert)
1 78L05 +5V 100mA voltage regulator (IC3)

**Capacitors**
1 22µF radial elect., 16V (C1)
1 100nF ceramic disc, 5mm pitch (C2)

**Resistors** (0.25W 5% carbon)
6 10k (R3 to R8)
2 1k (R1, R9)
1 470Ω (R2)

### RECEIVER

1 PC board, code 640 (Rec), available from the *EPE PCB Service*, size 104mm × 38mm
1 plastic case, size and type to individual choice
1 433MHz AM radio receiver module, type AM-HRR3-433 (RF Solutions) (IC5)
1 DPCO PC-mounting DIL relay; 5A AC switching, 5V coil (RLA1)
2 miniature push-to-make SP pushbutton switches (S6, S7)
1 6-way DIL switch or link wires – see text (S8)
1 12-pin DIL socket – see text
1 18-pin DIL socket
Multistrand connecting wire; 9V power source – see text; solder etc.

**Semiconductors**
2 1N4148 signal diodes (D4, D6)
1 3mm red LED (D5)
1 BC549 *NPN* transistor, or similar small-signal type (TR2, TR3)
1 78L05 +5V 100mA voltage regulator (IC4)
1 PIC16F627-4 preprogrammed microcontroller (IC6). (Ready-programmed PICs are available from Magenta Electronics – see their advert)

**Capacitors**
1 22µF radial elect., 16V (C3)
1 100nF ceramic disc, 5mm pitch (C4)

**Resistors** (0.25W 5% carbon)
6 10k (R10, R14 to R18)
2 1k (R11, R12)
1 470Ω (R13)

### 9V PSU (Optional)

1 PC board, code 641 (PSU), available from the *EPE PCB Service*, size 76mm × 38mm
1 230V AC mains transformer, with 6.3V AC 100mA minimum secondary (T1)
1 50V 1A bridge rectifier (REC1)
1 1A fuse and chassis fuseholder (FS1)
Mains cable, plug and socket to suit; solder pins; solder etc.

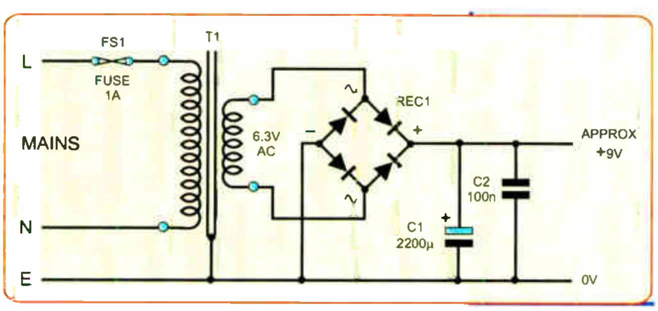
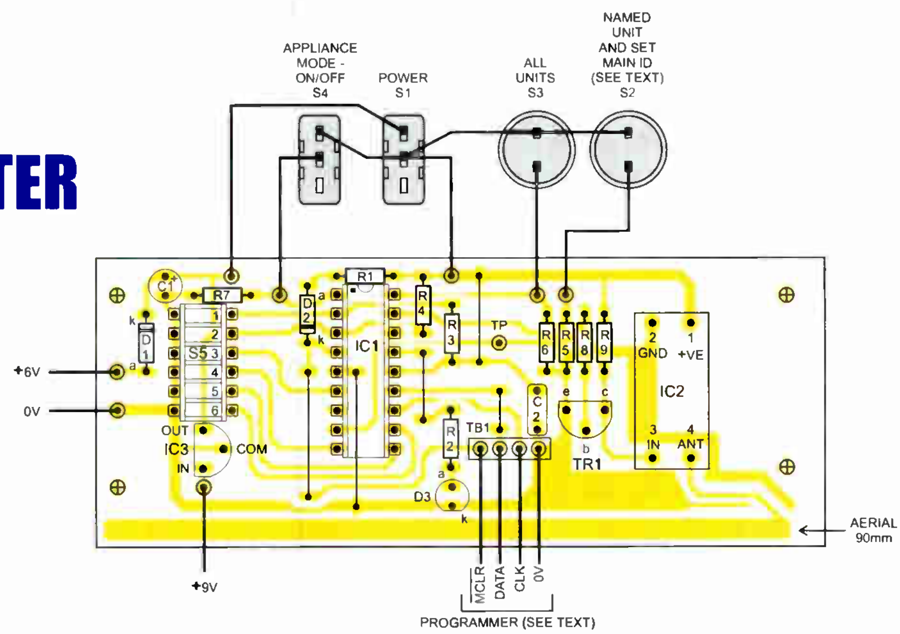



Fig.3. Suggested mains power supply circuit

# TRANSMITTER BOARD



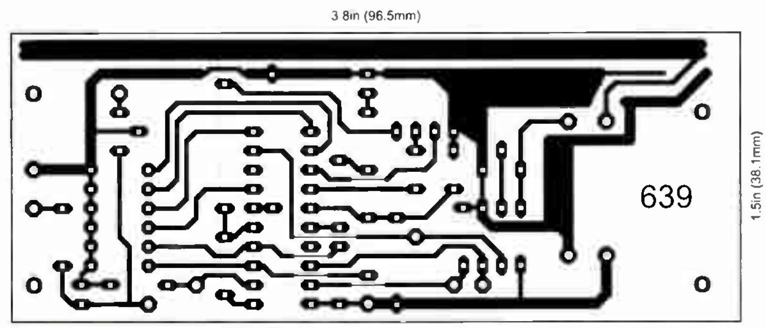
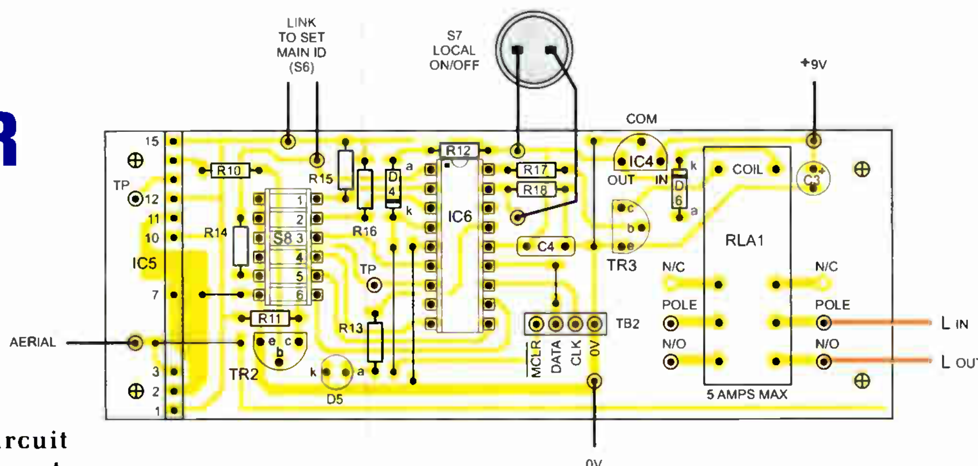




Fig.4: Printed circuit board topside component layout, interwiring details and full-size underside copper foil master for the transmitter unit

# RECEIVER BOARD



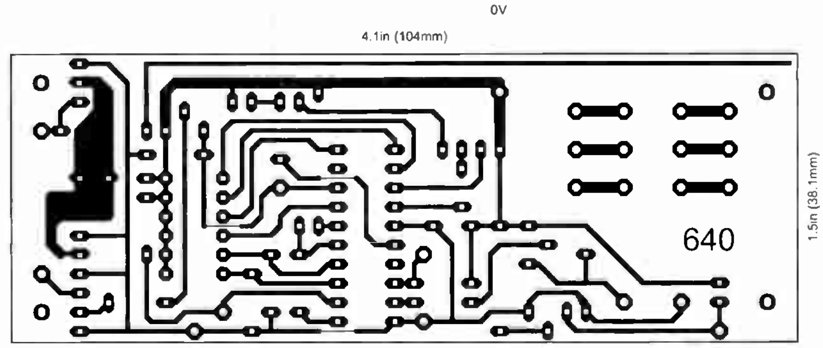
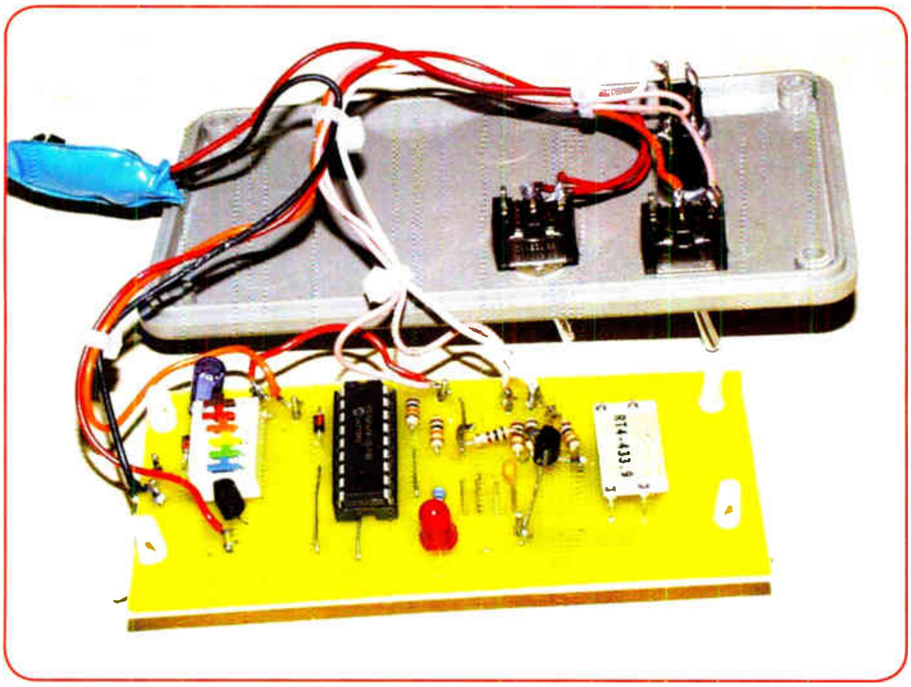




Fig.5: Printed circuit board component layout, full-size copper foil master and wiring details for a single receiver unit. You will, of course, require a receiver for each additional appliance. Note the relay contacts must be rated according to the appliance being controlled



**Prototype transmitter circuit board and function switches mounted on the lid of the case**

insert the DIL ICs until the correctness of the assembly and the power lines has been fully checked.

It is up to the user to decide whether Tx switch S5 is a DIL type mounted on the PCB, or separate SP toggle switches mounted on the top of the case. All Rx units may use link wires to set the required ID codes if desired.

The aerials are part of the PCB tracks. The aerial for the transmitter must not have its length changed in order to comply with regulations associated with the licence-free transmitter module. The receiver aerial can be extended if preferred.

Just an ordinary plastic case was used for the prototpe Tx unit. If preferred, a more sophisticated handheld case appropriate to TV control units may be used.

A plastic case must also be used for the Rx unit, ensuring that mains voltages cannot appear on external surfaces or switches etc. If the PSU PCB is used, keep a reasonable distance beween it and the Rx PCB. Mains cable must enter and leave the case by suitable locking grommets, and be terminated by suitable mains plugs and sockets.

If a different relay to the PCB mounting one suggested for the Rx unit is used, it must be adequately secured to the case side if it is not suitable for the DIL PCB mounting holes provided.

## Setting ID codes

If just a single Tx/Rx units pair is used, it is not necessary to set an individual ID code. Just ensure that switches S5 and S8 are set so that their PIC-connected pins are at 5V. This sets the ID code to a fixed value of 0 for the Main ID and 127 for the individual IDs. If you think that no-one in your neighbourhood might have a transmitter whose fequency may interfere with your receiver, then the Main ID code does not need setting.

However, if you discover that there is another transmitter upsetting the system. The Main ID code can be altered as follows:

Switch off power to the units and allow a few seconds for the smoothing capacitors to discharge.

For the Tx module, set the switches in S5 to the binary code of the Main ID you want between 0 and 63. The PIC automatically adds 64 to that value.

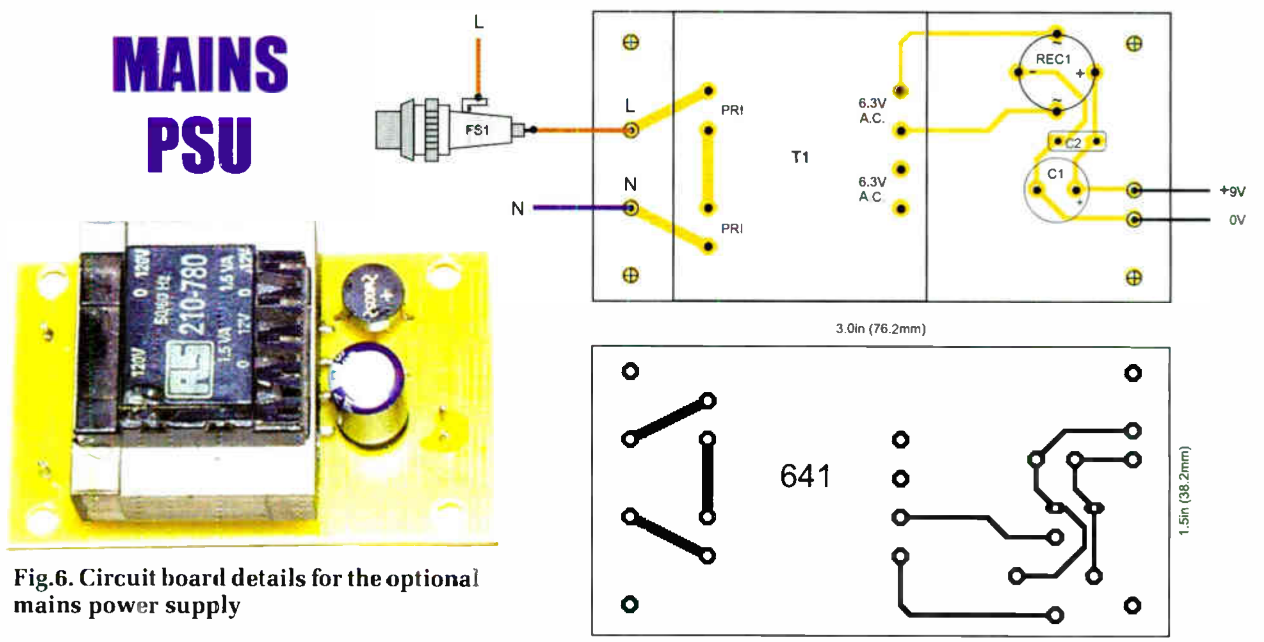



**Fig.6. Circuit board details for the optional mains power supply**

Press S2 and hold it pressed while power is switched on. Wait a couple of seconds and switch it off again. The Main ID code is now stored in the PIC's Data EEPROM for future recall.

For each Rx module, with the power off again, set the switches in S8 to the same binary code as set into the Tx module. Then press S6 and hold it pressed while power is reapplied for a couple of seconds or so. Then switch it off. The Main ID code is again stored in the PIC's Data EEPROM for future recall. Should you wish to change the Main ID at a later time, follow the same procedure.

For individual Rx modules, their specific ID codes can be changed at any time without any procedure, simply setting the binary switch or linking wires to the code required. When receiving data, the Rx modules only respond to that arriving and having the same specific ID.

Similarly with the Tx module, simply set the binary switches to the value for any particular Rx module. That code is then automatically sent when the Tx switch S2 is used.

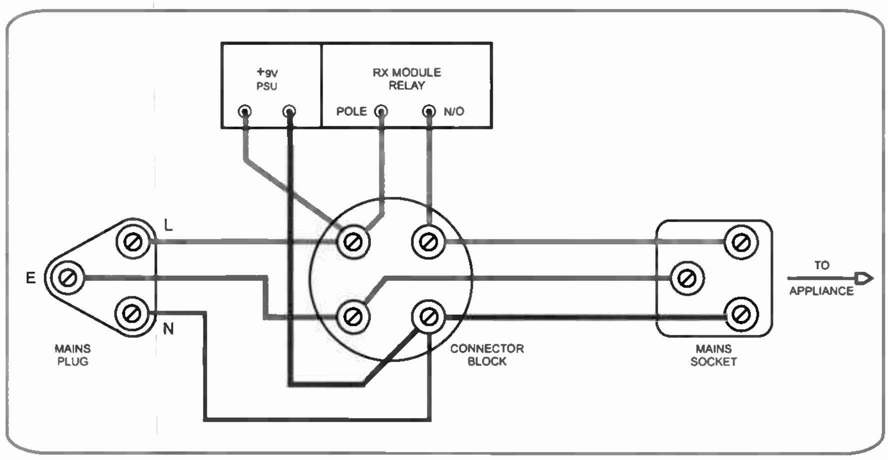



**Fig.7. Suggested wiring arrangement linking the receiver unit between the mains supply and the appliance to be controlled**

## Standby cost to the environment

Searching via **www.google.com** shows many sites relating to the costs to the environment of leaving TVs and other equipment in Standby mode.

The actual figures quoted vary slightly but are typically in the region of 24% of total TV and 50% of total VCR energy use. The average TV on standby consumes about 5W, drawing about 90% of normal energy.

Figures include the fact that 1TWh (terawatt/hour) of energy is lost annually and 800,000 tonnes of carbon are emitted to generate it. $CO_2$ emissions amount to the equivalent of 1.4 million long-haul flights. The average household has up to 12 gadgets left on standby or charging at any one time.

It is acknowledged that this design also uses energy, but that use is far less than that required by an appliance in standby mode. Even when batteries are used, there is still a cost to the environment by manufacturing them.

But it still makes sense to minimise the use of Standby mode. ***EPE***

# INTERFACE

## Robert Penfold

### SETTING PARALLEL PORT OUTPUTS TO INPUTS

THE previous *Interface* article covered the use of an eight-bit digital output plus one or two digital inputs to monitor up to 16 switches using a conventional diode gating and scanning technique. It is a technique that is commonly used as a means of reading keyboard switches, and it works well in most cases.

There can be problems when it is used with some types of digital input, such as those that have built-in pull-up resistors. The inputs of a PC's printer port usually have these resistors as a means of making their MOS-based circuits act more like the TTL types used in the original PCs. A 'floating' TTL input goes to logic 1 (high) due to the type of input circuit used, and pull-up resistors on MOS inputs give something that roughly approximates to the genuine article.

### Virtue out of a necessity

There can be problems if the pull-up resistors are quite low in value, as they can then interfere with a passive driver circuit, such as a simple keyboard scanning type based on diodes and resistors. One way around the problem is to make a virtue out of a necessity, and make the pull-up resistors part of the input circuit. This is the method used in the circuit of Fig.1, which functions in essentially the same manner as the basic scanning circuit described in the previous *Interface* article.

The basic scheme of things is to set each bit of the digital output high, in sequence, and to read the state of the digital input on each occasion. With this circuit, the pull-up resistor on the digital input normally takes it to logic 1.

However, when the switch for the active (high) output is closed, transistor TR1 will be biased into conduction and the input will be taken to logic 0. The scanning process therefore tests the state of each switch, with logic 1 being returned for an open switch, and logic 0 being returned for a switch that is closed.

Strictly speaking, the circuit is not a passive type, because it uses a switching transistor. No power supply is needed though, because the transistor is effectively powered from the PC's +5V supply via the pull-up resistors. The circuit is, therefore, as convenient as a conventional passive one that uses diodes, but no form of active switching device.

### Active extension

Like the passive version, the active circuit is easily extended to accommodate more switches. It is just a matter of using an additional circuit that is identical to the original, and can be driven from the same eight outputs. It feeds a different input though, and this input is used to read the eight additional switches.

In the circuit of Fig.2 switches S1 to S8 are read via the Select In handshake input, which is at bit 4 of the printer port's status register. Switches S9 to S16 are read using the Paper Empty (PE) handshake input at bit 5 of the status register.

There are five handshake inputs available at the printer port of a PC, which means that it should be possible to accommodate up to 40 switches in five banks of eight. It does not necessarily represent the best way of reading dozens of switches, but it is certainly

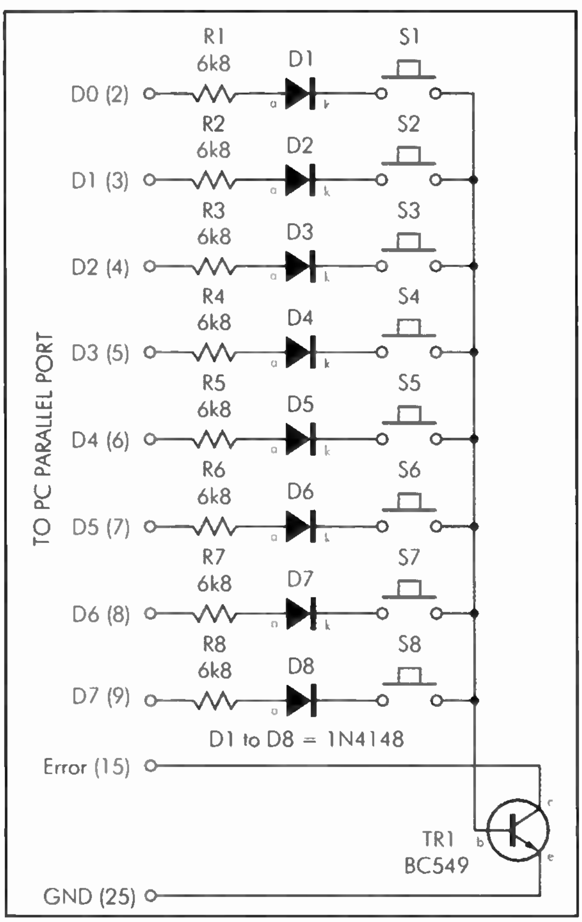



Fig.1. Simple 'active' circuit for monitoring eight switches

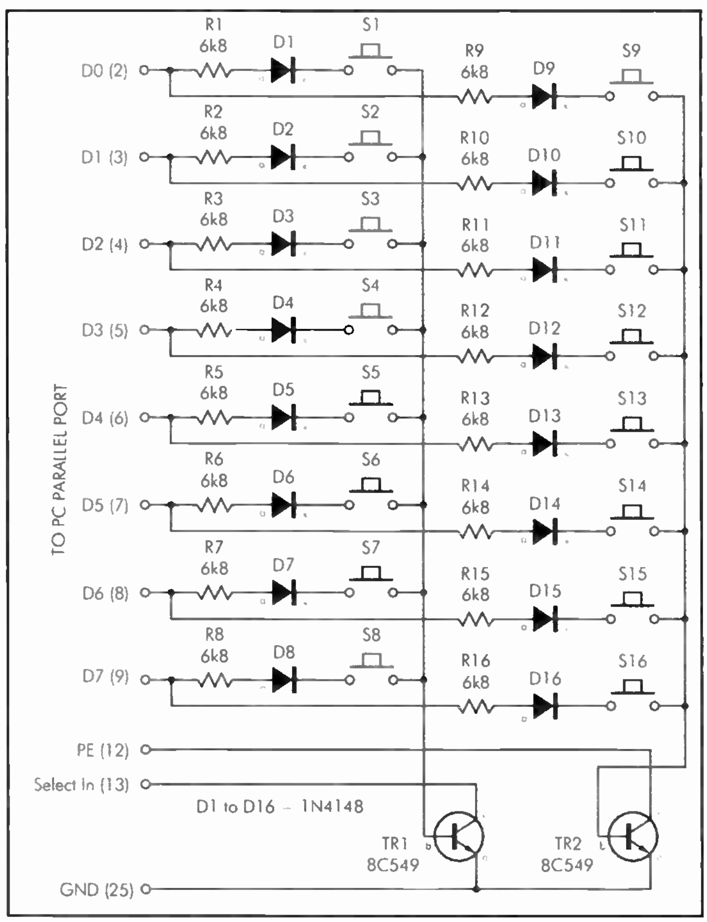



Fig.2. Extending the 'active' circuit to accomodate 16 switches

**Listing 1**

```
Private Sub Form_Load()
Out &H378, 0
End Sub

Private Sub Timer1_Timer()
Out &H378, 1
If (Inp(&H379) And 16) = 16 Then Shape1.FillColor = &HFF&
If (Inp(&H379) And 16) = 0  Then Shape1.FillColor = &HFF00&
If (Inp(&H379) And 32) = 32 Then Shape9.FillColor = &HFF&
If (Inp(&H379) And 32) = 0  Then Shape9.FillColor = &HFF00&

Out &H378, 2
If (Inp(&H379) And 16) = 16 Then Shape2.FillColor = &HFF&
If (Inp(&H379) And 16) = 0  Then Shape2.FillColor = &HFF00&
If (Inp(&H379) And 32) = 32 Then Shape10.FillColor = &HFF&
If (Inp(&H379) And 32) = 0  Then Shape10.FillColor = &HFF00&

Out &H378, 4
If (Inp(&H379) And 16) = 16 Then Shape3.FillColor = &HFF&
If (Inp(&H379) And 16) = 0  Then Shape3.FillColor = &HFF00&
If (Inp(&H379) And 32) = 32 Then Shape11.FillColor = &HFF&
If (Inp(&H379) And 32) = 0  Then Shape11.FillColor = &HFF00&

Out &H378, 8
If (Inp(&H379) And 16) = 16 Then Shape4.FillColor = &HFF&
If (Inp(&H379) And 16) = 0  Then Shape4.FillColor = &HFF00&
If (Inp(&H379) And 32) = 32 Then Shape12.FillColor = &HFF&
If (Inp(&H379) And 32) = 0  Then Shape12.FillColor = &HFF00&

Out &H378, 16
If (Inp(&H379) And 16) = 16 Then Shape5.FillColor = &HFF&
If (Inp(&H379) And 16) = 0  Then Shape5.FillColor = &HFF00&
If (Inp(&H379) And 32) = 32 Then Shape13.FillColor = &HFF&
If (Inp(&H379) And 32) = 0  Then Shape13.FillColor = &HFF00&

Out &H378, 32
If (Inp(&H379) And 16) = 16 Then Shape6.FillColor = &HFF&
If (Inp(&H379) And 16) = 0  Then Shape6.FillColor = &HFF00&
If (Inp(&H379) And 32) = 32 Then Shape14.FillColor = &HFF&
If (Inp(&H379) And 32) = 0  Then Shape14.FillColor = &HFF00&

Out &H378, 64
If (Inp(&H379) And 16) = 16 Then Shape7.FillColor = &HFF&
If (Inp(&H379) And 16) = 0  Then Shape7.FillColor = &HFF00&
If (Inp(&H379) And 32) = 32 Then Shape15.FillColor = &HFF&
If (Inp(&H379) And 32) = 0  Then Shape15.FillColor = &HFF00&

Out &H378, 128
If (Inp(&H379) And 16) = 16 Then Shape8.FillColor = &HFF&
If (Inp(&H379) And 16) = 0  Then Shape8.FillColor = &HFF00&
If (Inp(&H379) And 32) = 32 Then Shape16.FillColor = &HFF&
If (Inp(&H379) And 32) = 0  Then Shape16.FillColor = &HFF00&
```

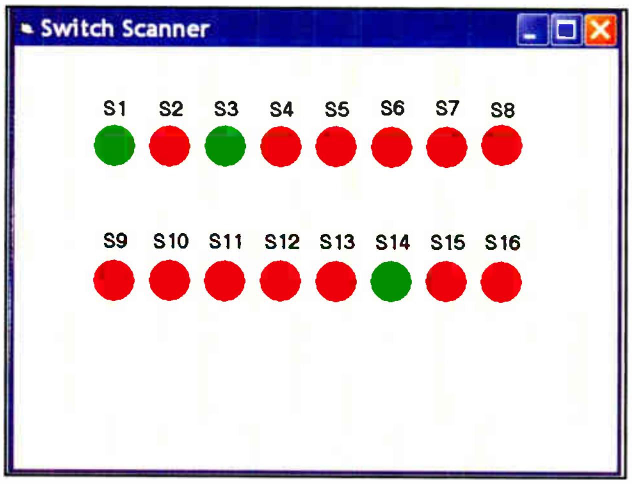



*Fig.3. Typical screen layout for scanning 16 switches. Red – switch open, and green –switch closed*

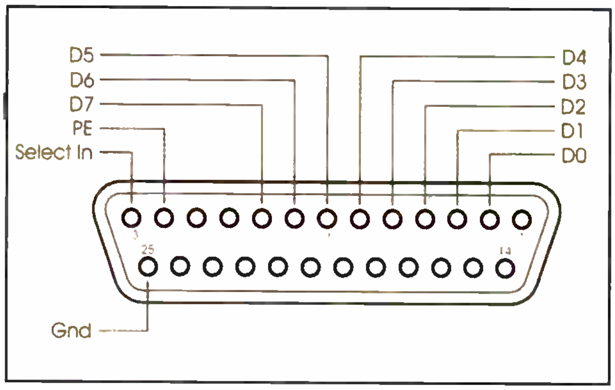



*Fig.4. Connections to the PC printer port are made via a 25-way male D-type connector*

possible to do so. A scanning system is unlikely to represent the fastest method of reading switches, but the highest possible operating speed is unlikely to be crucial when monitoring mechanical switches.

## Software

The Visual BASIC listing consists of eight main sections, with each one providing essentially the same action. It requires a form that has 16 shape components, which act as indicator 'lights' (Fig.3) on a one per switch basis. The colour of the 'light' is red when the corresponding switch is open, and green when it is closed.

A timer component is also required, and this should have a low Interval value of about 20 so that the program scans at a reasonably high rate. The program utilizes **inpout32.dll**, which must be available to the system in order to make the Inp and Out instructions function properly.

The first section of the program simply sets the output port with all the outputs initially low, which is not really necessary with this simple demonstration program since it starts the scanning process immediately. However, it could be important in applications that use the scanning process intermittently.

The next section is used to read switches S1 and S9, which are the switches that are read when output D0 is high. The first line writes a value of 1 to the output port, and it is assumed here that the port is at addresses from &H370 to &H37a. The addresses used in the Inp and Out instructions must be changed to suit in cases where an alternative address range is used.

Each switch is read by a pair of If....Then statements, which operate in the same basic manner. The first pair set the colour of Shape1 to red (&HFF&) or green (&HFF00&), depending on whether bit 4 of the status register is low or high. Bits of the register other than bit 4 are masked by using a bitwise And operation with a masking value of 16.

The second pair of If....Then statements are much the same, but they control the colour of Shape9, and a masking value of 32 is used in the And operations so that bit 5 of the status register is read and the other bits are masked.

The other seven sections of the program operate in the same fashion, but they control the colour of Shape 2 and Shape 10, Shape 3 and Shape 11, and so on through to Shape 8 and Shape 16. In a real-world application, it will usually be necessary to have the program do something more than control the colour of a shape component, but it is simply a matter of using the appropriate actions in the If... Then statements.

It would probably be possible to reduce the size of the program using a loop, but it is reasonably compact in its present form. Also, with the program in this form it is easy to make any switch provide practically any action. If necessary, each switch could have a totally different function.

The simple hardware of this interface is not particularly fast by the standards of modern logic, but it is still very fast when compared to a Visual BASIC program when running on even the best of current PCs. Consequently, there is no need to include any delay loops to give the interface time to respond to changes at the output port. Very short delays might be necessary if a fast programming language is used.

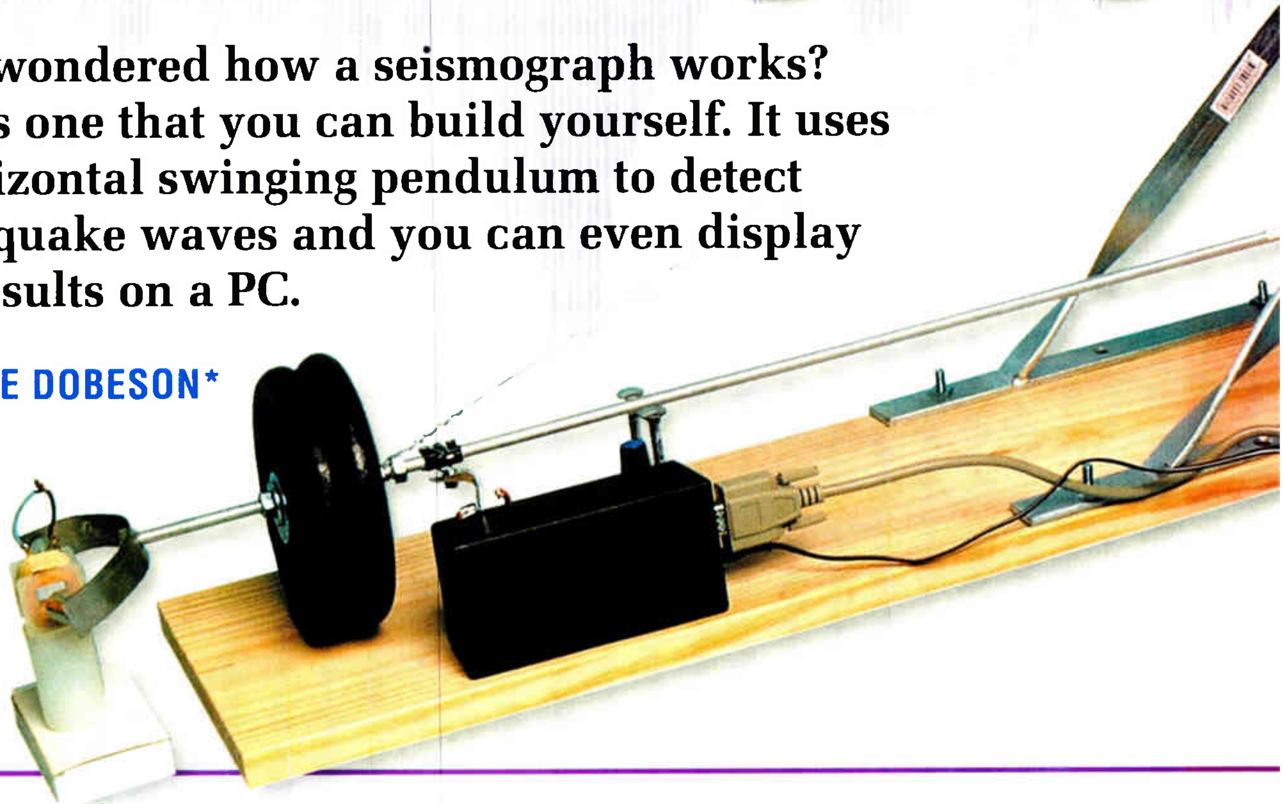
## Connections

The connections to a PC printer port are made via a male 25-way D connector, and Fig.4 shows the eleven connections that are needed in this case. As when using any circuit that interfaces to the PC via a simple parallel port, the connecting lead should be no more than about two or three metres long. Otherwise there is a risk of stray coupling between the leads causing erratic results.

# Build Your Own Seismograph

**Ever wondered how a seismograph works? Here's one that you can build yourself. It uses a horizontal swinging pendulum to detect earthquake waves and you can even display the results on a PC.**

By DAVE DOBESON*



MOST Britains are thankful that we are not seriously affected by the large earthquakes and volcanoes that regularly devastate so many other parts of the world. However, few realise how easy it is to make your own amateur seismograph.

## Plate tectonics

Before we take a look at the design of our seismograph, let's first find out why major earthquakes occur. In particular, we need to have some understanding of 'plate tectonics'.

The basics are very simple – the crust of the earth is made up of about 20 major 'plates' that 'float' on semi-liquid layers underneath. Earthquakes commonly occur at the boundaries of the plates, where they collide and produce stresses in the Earth's crust. For example, deep ocean faults off the coast of Sumatra produced the magnitude 9.0 'Boxing Day Tsunami' earthquake in 2004 and the related Niass 8.7 earthquake in April, 2005.

Of course, many large earthquakes go unreported because they occur under the ocean or in sparsely populated areas and have no impact on humans.

If you look at the United States Geographical Survey (USGS) home page and click on 'Latest Earthquakes' (to show the last seven days' earthquakes for the US and the world), you will see where many of the larger earthquakes occur – see **www.usgs.gov**.

The site also has detailed information on the tectonic forces causing earthquakes, the design and operation of professional seismographs, records of historically significant quakes and links to records in other countries.

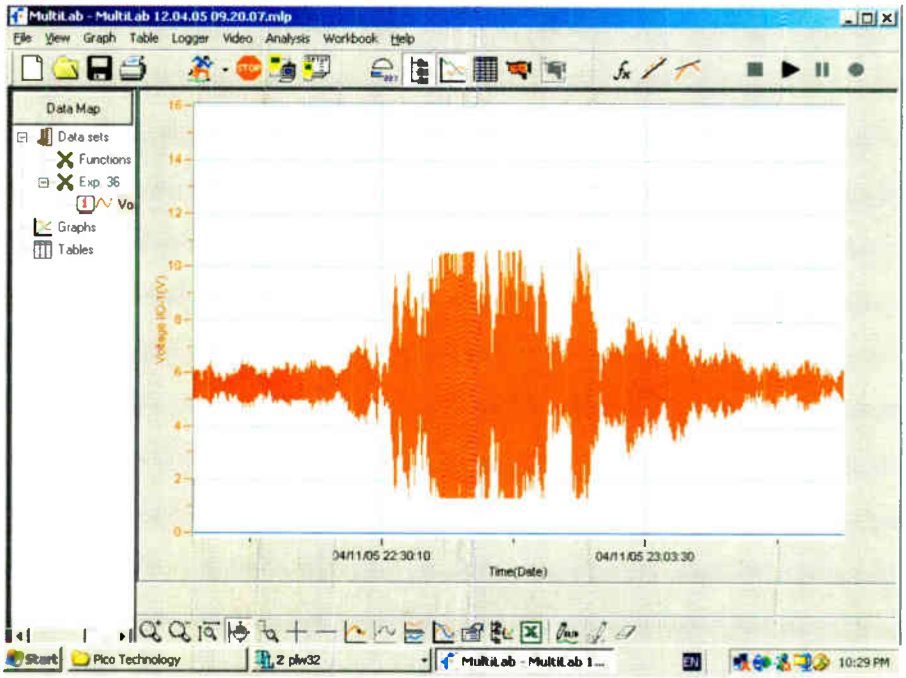
If your home-made seismograph detects a real earthquake, the event should also be reported within minutes by the above site.

## Designed for schools

This do-it-yourself seismograph was originally described in *Scientific American* in 1979 and has been adapted for science teachers to build and use in the school laboratory.

Movements of the seismograph, which is basically a horizontal pendulum, are detected using a simple light sensor circuit. In operation, a metal vane attached to one end of the pendulum

The mechanical section of the seismograph uses parts that are readily available from a hardware store. It's based on a swinging horizontal pendulum and movement is detected using a vane and light sensor circuit mounted at one end.




**This seismograph plot shows a magnitude 6.5 quake that occurred in Papua New Guinea on April 11, 2005. A 6.8 quake near Noumea was detected only five hours later. The detector circuit used was the same as described here.**

(or bar) partially blocks the light between a LED and an LDR (light-dependant resistor). However, when the bar moves (ie. during an earthquake), the amount of light falling on the LDR is modulated by the metal vane.

This signal is then fed to a low-cost op amp circuit which, in turn, feeds into a data logger. Finally, the output of the data logger is fed to a computer to store, display and print the results. A PICAXE-based A/D converter and a freeware graphing program called 'StampPlot Lite' can do the same job.

## Building the seismograph

OK, let's first take a look at the mechanical details of our seismograph and find out how it's built.

The seismograph described here is known as a 'Lehman' or 'Horizontal Pendulum' seismograph. It's also called a 'Swinging Gate Seismograph', because the bar and its supporting wire look like an old-fashioned farm gate. The 'hinges' (actually the pivot points) of the 'gate' are not quite vertically aligned, with the top hinge just forward of the bottom hinge so that the 'gate' will swing shut. In practice, this means that the horizontal pendulum (or bar) swings slowly back to its original resting position

The accompanying photos show the basic set-up. As can be seen, it includes an 800mm long 16mm threaded steel rod that's fitted with a 2 to 3kg mass at one end. The other end of the rod is ground to an edge and pivots on the end of a 13mm bolt – this forms the lower pivot point.

The supporting wire is attached to the rod at one end, just before the weights, and to a turnbuckle at the other end. This then pivots about 25-35cm above the lower pivot.

If we align the seismograph pivots so that the top pivot is less than 1mm forward of the bottom pivot, then the seismograph bar will always swing back to its central position and will have a natural period of about 5-10 seconds. However, if the pivots are exactly vertically aligned, there will be no restoring force and it will never swing back. We cannot move the top pivot too far forward though, otherwise the seismograph will be very insensitive.

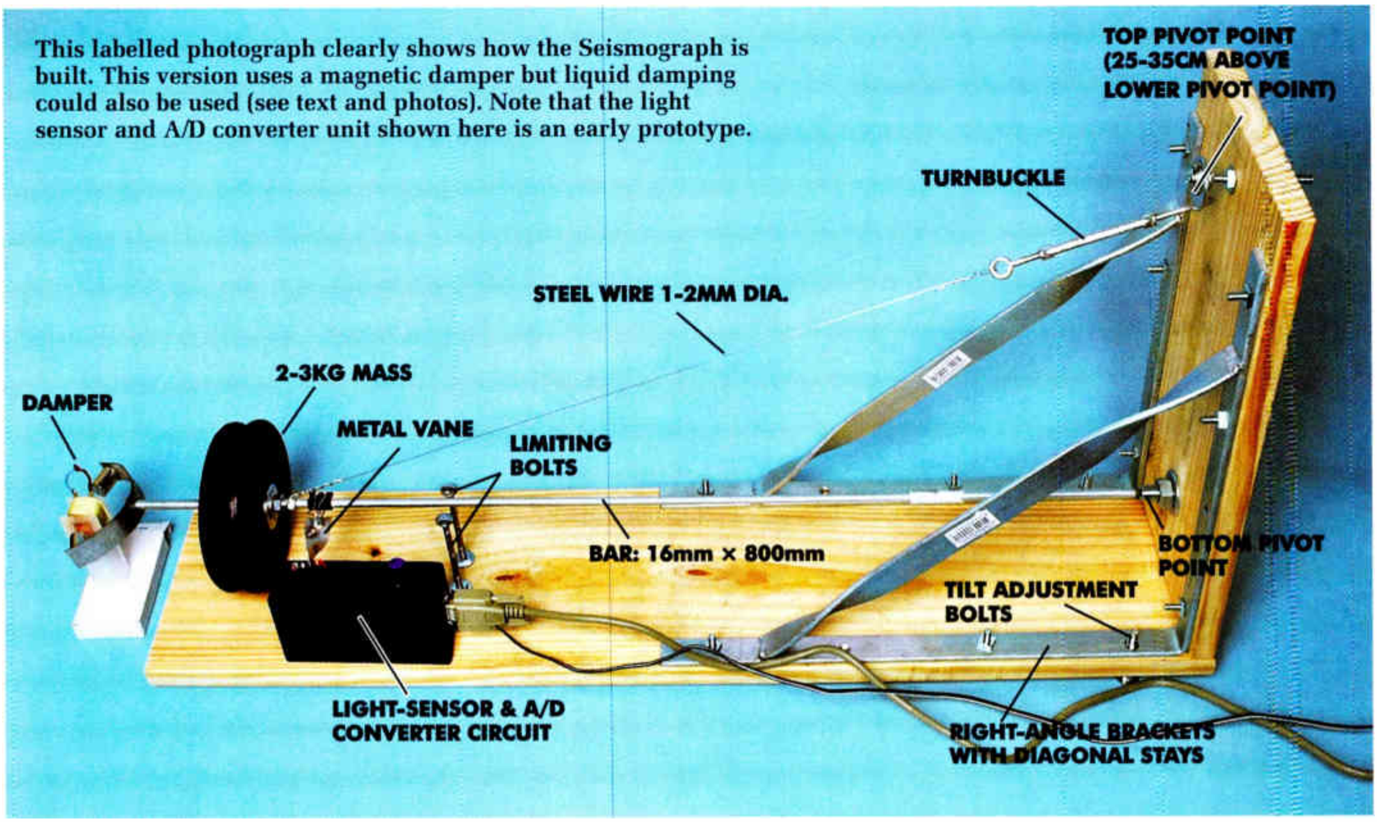
This unit is very sensitive to the mostly horizontal motion of earthquake 'L-waves' but is insensitive to 'P-waves', which are mostly vertical.

By the way, it's important to remember that although we often talk about the bar (or pendulum) of the seismograph 'swinging', it's really the room that moves during an earthquake. The bar, because of the inertia of a heavy mass attached to one end, initially stays still. In effect, the unit and its associated logger act as a low-pass filter which renders the unit insensitive to everyday events (footsteps, doors closing, passing traffic, etc).

The accompanying photos show most of the construction details. The only critical dimension is that the top pivot must be less than 1mm in front of the lower pivot. As well as the wooden

### About The Author*

Dave Dobeson is a science teacher at Turramurra High School, Australia and the University of Sydney Science Teacher Fellowship holder for 2005.




**This labelled photograph clearly shows how the Seismograph is built. This version uses a magnetic damper but liquid damping could also be used (see text and photos). Note that the light sensor and A/D converter unit shown here is an early prototype.**

frame shown, the unit could be built into any strong cupboard, bookcase, shelf or even a strong, metal frame. In that case, the brackets and wooden frame would not be needed. Any type of metal rod could be used (as long as it's strong enough) and the same goes for the mass at one end.

Note that you will have to 're-zero' the seismograph for the first few weeks after building it, as the wire, brackets and wood flex under the strain. After that, it will be a matter of making routine adjustments every few months.

## Top pivot point

The top 'hinge' (or pivot point) is made by drilling a 5mm diameter hole about half-way through the outer section of a large, thick washer – ie, to make a 'dimple'. Smaller washers and a nut are used to hold the large washer in position, while a nut and lockwasher behind the wooden upright panel lock the bolt in place.

As shown in the photos, the hook at the end of the turnbuckle sits in this dimple, so that it can pivot freely. In operation, the turnbuckle adjusts the tilt of the bar and is set so that the bar is horizontal. The securing bolt can be screwed in or out to move the top pivot point relative to the bottom pivot. This is important for the overall functioning of the seismograph because it affects the natural period of the bar (ie, the time for one complete swing from the centre to one side, then back through the centre to the other side and finally back to the centre again).

A period of about five seconds seems to work best.

The pivot end of the 16mm threaded rod is ground to a knife-edge and this sits vertically against the end of a 13mm bolt. Wind a nut onto the rod before you cut and grind it, so that the thread is restored when the nut is removed. Be sure to use safety goggles when drilling, cutting or grinding metals – you only have one pair of eyes.

Note that the lower mounting point must be directly below the upper mounting point. The best way to ensure this is to use a plumb-bob made from fine fishing line and a lead sinker.

The two rear-most vertical bolts that go through the support brackets are used for tilt adjustment – see photo. These both screw into threads that are tapped through the wooden base and the brackets (nuts under the wooden base will do) and each has a screwdriver slot cut into its end. This allows you to use a screwdriver to tilt the seismograph sideways and forwards or backwards, to alter the position of the bar and thus its period and sensitivity.

The far end of the seismograph wooden frame has a single central support. A sheet of plywood underneath will stop the three supports from sinking into the carpet when the unit is positioned on the floor.

## Swinging the weight

Just about any mass of 2 to 3kg will provide sufficient inertia to initially keep the bar still during an earthquake, provided it doesn't hang too far below the bar. A pair of 1.25kg barbell weights are ideal for the job. They cost less than £3 each from a sports store and come with a ready-made hole through the middle. This means they can be simply slipped over the end of the bar and clamped in position using nuts and washers on either side.

## Damping

Once earthquake waves set the bar swinging, it will keep swinging for hours unless it is damped. Perfect damping would stop the bar with a few swings but in practice, under two to three minutes is OK.

You can use either liquid or magnetic damping. For liquid damping, a 40 × 50mm plastic paddle dipped into a rectangular container of water will do the job. You can use a small bulldog clip to attach the paddle to the bar (see bottom right). The water will need topping up each week or so.

Magnetic damping involves attaching one or two super magnets to the end of the bar using a U-shaped bracket. A thick sheet of aluminium or a coil of wire with the ends joined is then placed in the magnetic field.

When the bar moves (ie, during an earthquake), current is induced into the aluminium or wire coil. This in turn produces a magnetic field that counters the magnets and so damps the motion of the bar.

Discarded computer hard disks are a good source for super magnets but be careful – supermagnets are dangerous and the author has been badly cut when a pair decided to play 'north attracts south, with his hand in between'. They can also be a disaster if they get too close to your credit cards or a computer monitor!

On the other hand, the good thing about magnetic damping is that once you get it right, it stays right.

Old aquarium air pumps have coils of fine wire, which can be used for magnetic damping if the ends of the wires are joined together. A 400g coil of 0.7mm enamelled wire with the ends joined together and a super magnet that moves inside the coil gives almost perfect damping.

Use your multimeter to check that the winding hasn't burnt out before using the coil.

The perfect location for your seismograph is on a concrete block that's set into bedrock at the bottom of a sealed mine shaft! If you don't have access to a mine shaft(!), the seismograph should be installed in a closed room or cupboard, or in a strong bookcase surrounded by a Perspex cover (to prevent air movement over the unit).

## Circuit details

Many different seismograph detector and A/D (analogue-to-digital) converter circuits are available on the net. The best-known site is called the Public Seismic Network at **www.psn.quake.net** (in California). It has designs that go from pens writing on rolls of paper to very complex circuits with low-noise op amps, 16-bit A/D converters and damping using negative feedback.

By contrast, the circuit used here is quite simple – see Fig.1. As previously stated, it's based on a light sensor circuit that's interrupted by a metal vane attached to the end of the bar. In practice, the unit is set up so that the vane normally blocks about half the light from the LED to its LDR.

The light detector and its associated op amp circuit is exactly the same as the one designed for use with some school data loggers. The logger output is simply taken from the output of IC1, as shown. Alternatively, you can add your own data logger, based on A/D converter stage IC2 (a PICAXE-08M).

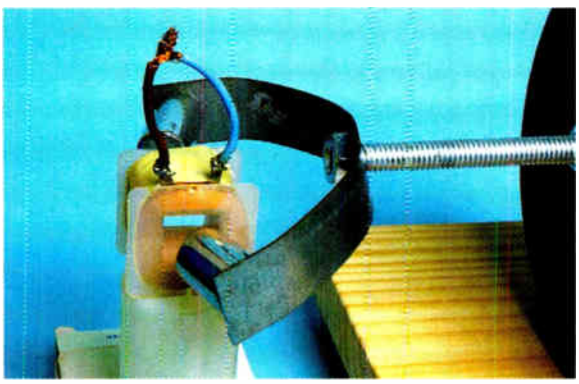
In greater detail, power for the circuit comes from a 9V DC plugpack supply. Diode D1 provides reverse polarity protection, while the associated 100Ω resistor and 470µF capacitor provide decoupling and ripple filtering.

The filtered DC rail is used to power LED1 via a 1kΩ current limiting resistor. The LDR and its associated 10kΩ resistor effectively form a voltage divider across this supply rail, the voltage at their junction varying according to the resistance of the LDR. This in turn depends on the amount of light reaching it from the LED.

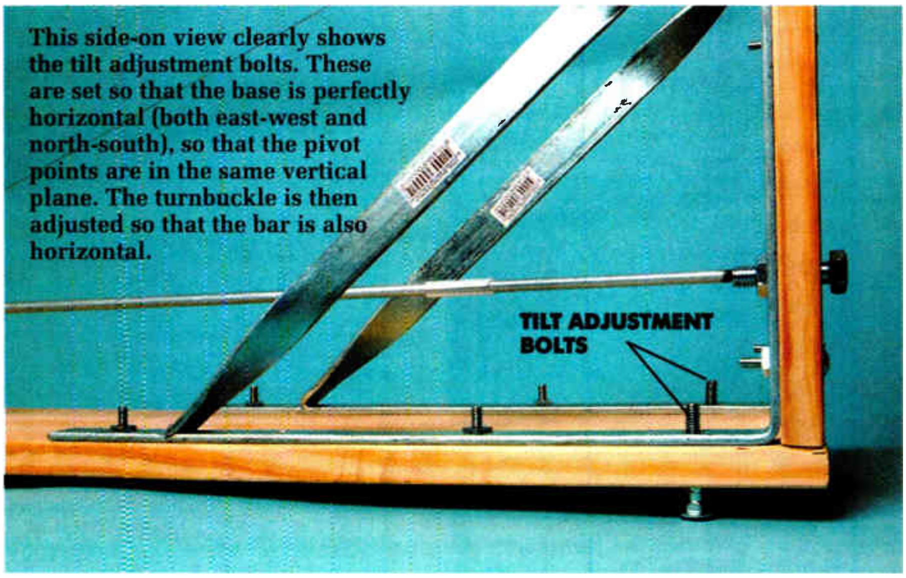
The output from the LDR is fed to the inverting (pin 2) input of op amp

**The hook at the end of the turnbuckle sits in a 5mm dimple that's drilled into a large washer to form the top pivot point.**

**The lower pivot point is formed by first grinding the end of the bar to a sharp edge. This sharp edge then rests vertically against the end of a 13mm × 40mm-long bolt.**



**Above and right: these two views show the alternative damping methods for the swinging bar. Magnetic damping (above) uses a couple of super magnets and a coil of wire, while liquid damping (right) uses a 40 × 50mm plastic paddle dipped into a rectangular container of water.**



This side-on view clearly shows the tilt adjustment bolts. These are set so that the base is perfectly horizontal (both east-west and north-south), so that the pivot points are in the same vertical plane. The turnbuckle is then adjusted so that the bar is also horizontal.

IC1 (741) via two back-to-back 470µF capacitors. These capacitors block the DC component at the output of the LDR, while allowing signal fluctuations to be fed to the op amp. They also block any slow variations in the LDR signal due to thermal variations in the room.

IC1 functions as an inverting amplifier stage. Its non-inverting input (pin 3) is biased to half the supply voltage using two 10kΩ resistors, while its gain can be varied from 0 to 10 using potentiometer VR1, which is in the feedback loop.

Note that although the circuit shows a 741 op amp, you could also use an OP27 device for improved accuracy.

IC1's output appears at pin 6 and is fed to a voltage divider consisting of two 3.3kΩ resistors. The top of this divider (ie, at pin 6) can be used to directly drive an external data logger. Alternatively, the divider output (at the junction of the resistors) can be used to provide a nominal 0-5V signal, which may be required by some loggers.

Pin 6 of IC1 also drives trimpot VR2 and this is used to set the maximum signal level into pin 3 of IC2 (to about 4V). IC2 is programmed to function as an A/D converter, using the simple program, Listing 1, in the accompanying panel (more on this later). Its output is taken from pin 7 (P0) and fed to pin 2 of DBF9 socket CON2.

This socket is in turn connected to the serial port of a PC, to provide the alternative data logger.

The PICAXE-08M is programmed via pin 3 of CON2 socket. The incoming data signal is fed to pin 2 (SER IN) of IC2 via a voltage divider consisting of 22kΩ and 10kΩ resistors.

Power for IC2 is supplied via a 3-terminal voltage regulator REG1. This provides a regulated +5V rail to pin 1.

## Building the circuit

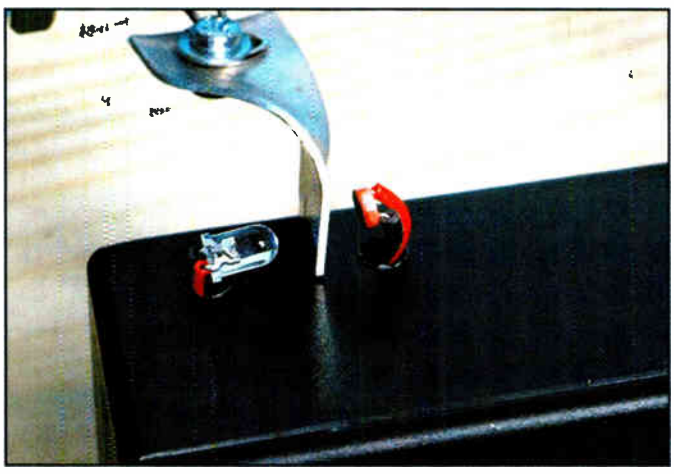
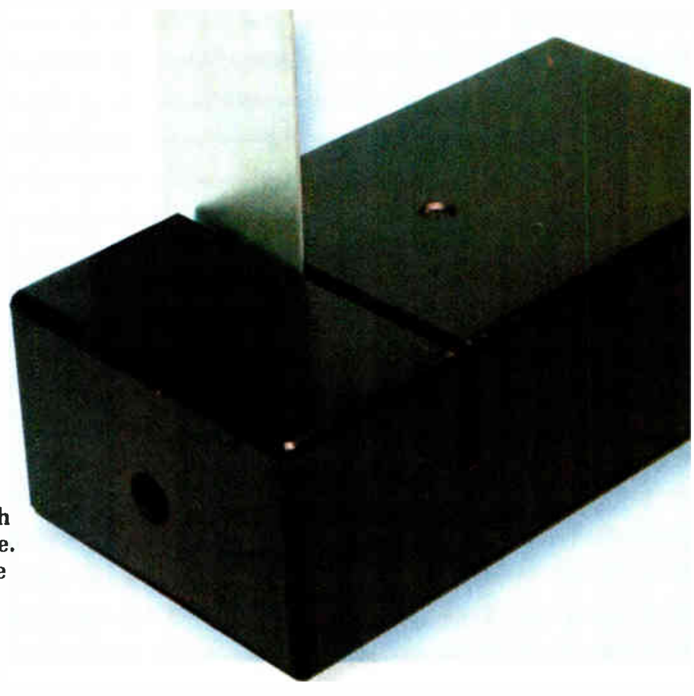
Building the circuit is easy since all the parts are mounted on a small PC board, coded 636. Fig.2 shows the assembly details.

Note that REG1 and the PICAXE (IC2) are required only if you don't already have a data logger. If you do have a logger, these parts can simply be left out, along with the DB9F socket, trimpot VR2, the 100nF capacitor and the 22kΩ and 10kΩ voltage divider resistors from pin 2 of IC2.

Begin by installing the resistors and capacitors. Table 1 shows the resistor colour codes but it's also a good idea to check each resistor using a digital multimeter before soldering them into circuit, just to make sure.

Follow these parts with diode D1, the two IC sockets (don't install the ICs yet) and trimpot VR2. Take care to ensure that D1 and the electrolytic capacitors go in the right way around.

LED1 can go in next. Bend its leads down through 90° close to its body before installing it at full lead length on the PC board – ie, the centre of the LED should be about 22mm above the PC board (see photo). Again, take care to ensure that it's oriented correctly.



In the prototype, the LED and the LDR were brought out through holes in the case, with the vane sitting between them – see above. By contrast, in the final version, the LED and LDR are inside the case and the vane rides in a slot. The vane is positioned so that it normally 'shadows' about half the LED body.

That done, you can install the LDR but there's just one wrinkle here. The 10kΩ resistor shown in series with the LDR on Fig.1 is correct for most LDRs. However, some LDRs have a lower resistance than others in the presence of light and you may have to adjust the value of the series resistor accordingly.

That's easy to do – just measure the resistance of the LDR in a brightly lit room and use a series resistor that's about the same value. The value isn't all that critical. In practice, you can buy 1kΩ, 3.3kΩ and 10kΩ resistors and use the one that's closest to the measured LDR value.

The LDR is mounted in similar fashion to the LED – ie, bend its leads down through 90° before installing it. It should be mounted so that its face is directly aligned with the LED.

Regulator REG1 is mounted with its metal tab flat against the PC board. To do this, bend its leads downwards by 90° about 5mm from its body, then secure it to the board using a M3 × 6mm machine screw and nut before soldering its leads. There's no need for a heatsink, as it supplies just a few milliamps to IC2.

The board assembly can now be completed by fitting CON1, CON2, potentiometer VR1 and a 3-pin header for the external logger interface.

## Parts List – Simple Seismograph

1 PC board, code 636, available from the *EPE PCB Service*, size 123 x 57mm
1 9V DC plugpack
1 2.1mm DC power socket, to suit plugpack (CON1)
1 DB9F connector, PC mount
1 plastic utility box, 130 x 67 x 44mm
4 9mm-long untapped spacers
4 M3 x 15mm machine screws
4 M3 nuts
3 PC stakes
1 serial computer cable (see text)
2 8-pin IC sockets
1 100kΩ rotary potentiometer, linear (VR1)
1 5kΩ horizontal trimpot (VR2)
1 Light Dependent Resistor (LDR1)
1 3-way pin header

**Semiconductors**
1 741 or OP27 op amp (IC1)
1 PICAXE-08M microcontroller (IC2) **www.picaxe.co.uk**
1 7805 3-terminal + 5V voltage regulator (REG1)
1 1N4004 diode (D1)
1 red or white high-brightness LED (LED1)

**Capacitors**
3 470µF 25V electrolytic
1 100nF MKT (code 104 or 100n)

**Resistors (0.25W, 1%)**
1 22kΩ  1 1kΩ
4 10kΩ  1 100Ω
2 3.3kΩ
Plus 1 x 10kΩ or 1 x 3.3kΩ or 1 x 1kΩ to match LDR resistance – see text

**Mechanical Parts**
1 800mm long x 16mm threaded steel rod
5 16mm nuts and washers to suit rod
1 50mm long x 6.5mm bolt
3 6.5mm nuts and washers
1 40mm long x 13mm bolt
1 13mm nut and washers
1 9.75mm washer
1 1-metre length 1-2mm diameter steel wire
2 bulldog clips to suit
1 2-2.5kg mass (eg, 2 x 1.25kg barbell weights)
1 piece of thin aluminium sheet (to interrupt light beam)
1 50 x 50mm piece of aluminium or rigid plastic for paddle (see text)
2 small bolts and nuts to fasten paddle to bulldog clips
2 braced right-angle brackets, 250 x 250mm
8 6.5mm x 40mm bolts, nuts and washers
3 16mm x 100mm round-head bolts, nuts and washers
1 wooden base, 900 x 250 x 20mm
1 wooden back, 400 x 250 x 20mm

## Serial cable options

A standard serial cable is used to connect the PC board to the computer (if you're using a PC as the data logger). There are several options here.

First, you could go out and buy a serial cable but that's the expensive way of doing things. It's far better to scrounge a cable instead. For example, if you have an old modem (left over from your dial-up days), you can use its serial cable (you did keep it, didn't you?) to connect to the PC.

Another possibility is to use a serial cable from a discarded mouse. Just cut the cable off close to the mouse, then strip the wires back and use a multimeter to identify which lead goes to which pin on the socket – you need to use the leads that go to pins 2, 3 and 5 (the rest can be trimmed off).

These leads can then be soldered directly to three PC stakes mounted at the appropriate points on the PC board. As a bonus, you don't need the on-board DBF9 socket, which means you can save even more money.

## Checks and adjustments

Before fitting the two ICs, it's necessary to make several voltage checks. First, connect a 9V DC plugpack supply and switch on. The LED should immediately come on. If necessary, adjust it so that it shines directly on the LDR.

## Table 1: Resistor Colour Codes

| | No. | Value | 4-Band Code (1%) | 5-Band Code (1%) |
|---|---|---|---|---|
| ❑ | 1 | 22kΩ | red red orange brown | red red black red brown |
| ❑ | 4 | 10kΩ | brown black orange brown | brown black black red brown |
| ❑ | 2 | 1kΩ | brown black red brown | brown black black brown brown |
| ❑ | 1 | 100Ω | brown black brown brown | brown black black black brown |

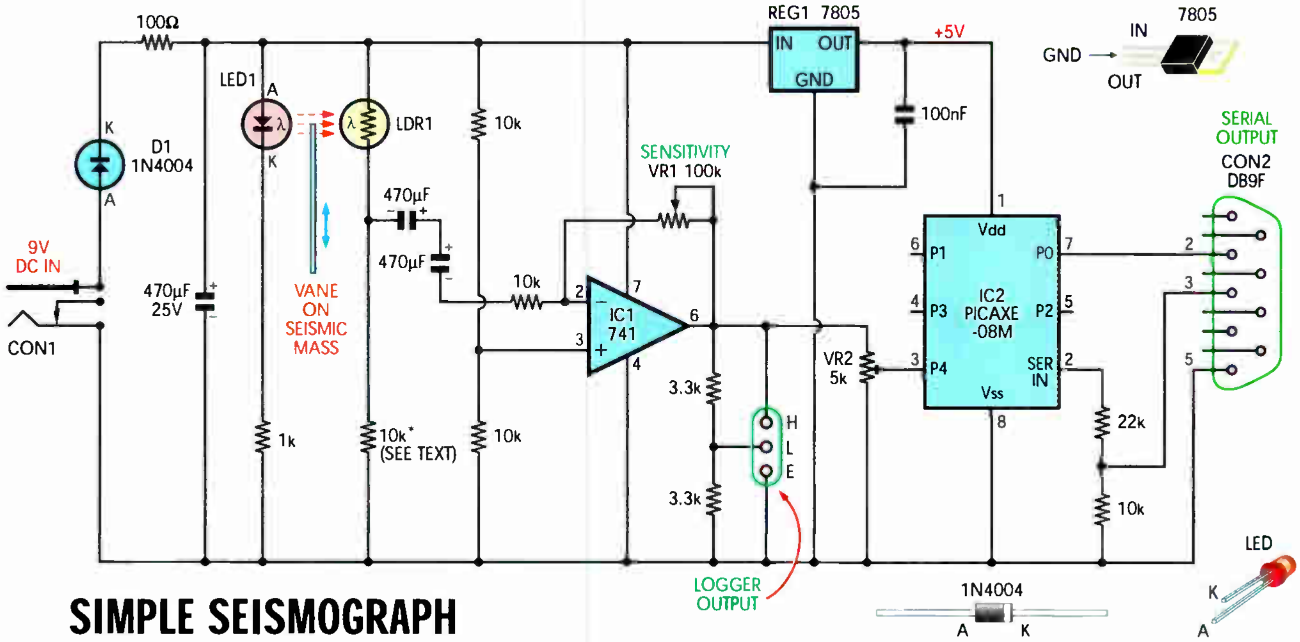



Fig.1: the circuit uses a light detector based on LED1 and LDR1 to detect movement of an interrupter vane placed between them. The resulting signal is then amplified by IC1 and fed to the logger output. IC1 also drives IC2, a PICAXE-08M chip programmed to function as an A/D converter. Its output can then be fed to the serial input of a PC, to provide an alternative data logger.

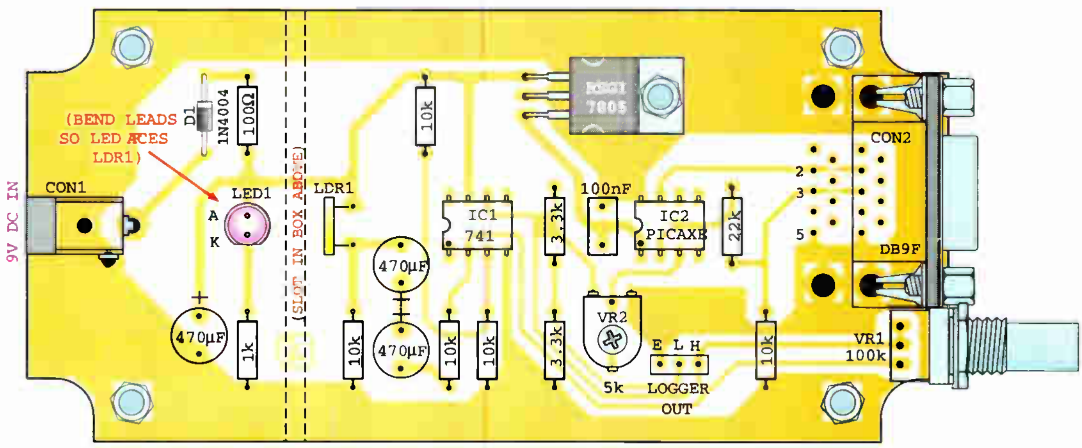



Fig.2: install the parts on the PC board as shown here, making sure that all polarised parts are correctly oriented. IC2, REG1, VR2 and CON2 can be left out if you already have an external data logger.

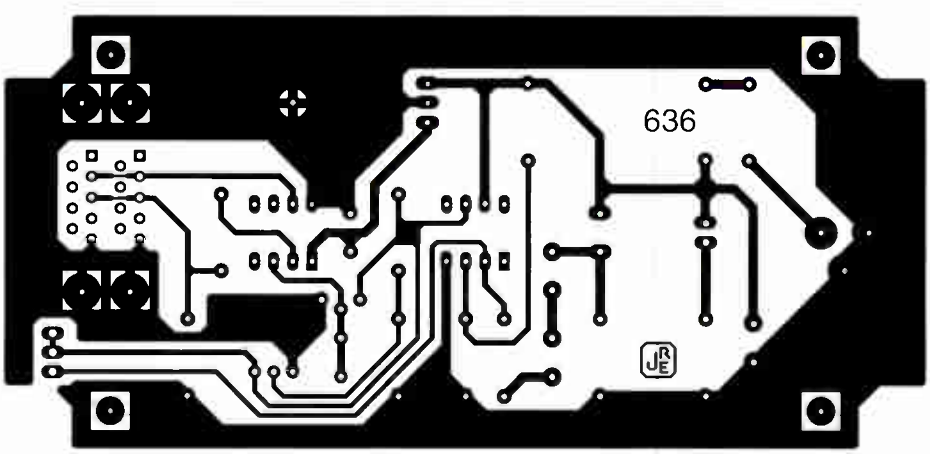
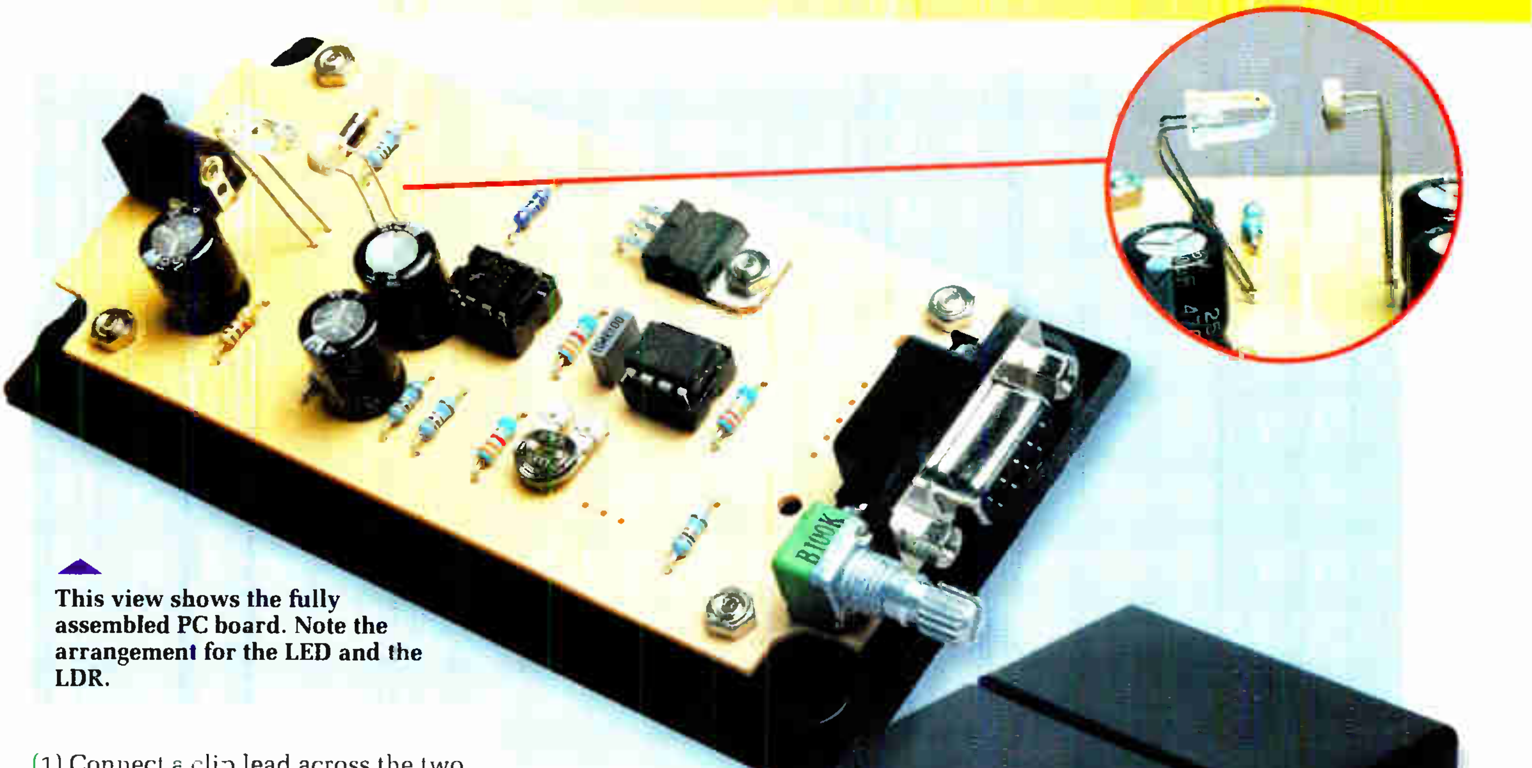



Fig.3: this is the full-size etching pattern for the Seismograph PC board.

Next, use a digital multimeter to check the voltages on IC1's socket pins. Pin 7 should be at the supply voltage (about 9V, depending on the plugpack), pin 2 should change when the light to the LDR is suddenly interrupted and pin 3 should be at half the supply voltage. That done, check for +5V on pin 1 of IC2's socket and for 0V on pins 2, 3, 7 and 8.

If it all checks out so far, disconnect the plugpack and install IC1 (but not IC2). You now have to adjust trimpot VR2 so that the voltage on pin 3 of IC2 can never exceed 5V. This is done as follows:




This view shows the fully assembled PC board. Note the arrangement for the LED and the LDR.

Above: a slot is cut into one end of the case to provide access for the metal vane that's attached to the seisomograph bar.

(1) Connect a clip lead across the two back-to-back 470µF capacitors (ie, short them out)

(2) Set both VR1 and VR2 to their mid-range positions

(3) Place a piece of thick cardboard (or other opaque object) between the LED and the LDR (to block the light)

(4) Reapply power and check the voltage at pin 6 of IC1. It should be about 1V less than the supply rail

(5) Monitor the voltage at pin 3 of IC2's socket and adjust VR2 for a reading of 4V (or slightly less).

Once that's done, disconnect the plug-pack and install the PICAXE-08M, with its notch facing to the left – see Fig.2.

## Final assembly

The PC board is designed to fit inside a standard (130 × 67 × 44mm) plastic case. It's mounted on the lid on four 9mm untapped spacers and secured using M3 × 15mm long screws and nuts.

That done, you have to make a cutout in one end of the case to provide clearance for the DBF9 socket (CON2) and the pot shaft. This cutout measures 45mm long × 12mm high and is about 12mm from the lip of the base.

Alternatively, if you're not using CON2, the serial cable can be run through a small hole in the case and secured using a small cable tie. The same applies if you are connecting an external logger to the 3-pin header.

You also need a hole directly in-line with the DC power socket (CON1). This is horizontally centred 17mm from the lip of the case and should be drilled and reamed to 8mm.

Finally, a slot must be cut in the case, in line with the light sensor, to provide access for the vane that's attached to the bar. This slot should be positioned 37mm from the end of the case and can be about 4mm wide. The unit can then be assembled into the case and attached to the base of the seismograph.

Position the vane so that it normally blocks about half the light between the LED and the LDR.

## Programming the PICAXE

To program the PICAXE, you first have to download the free 'Programming Editor' from **www.rev-ed.co.uk/picaxe**.

That done, connect the board to your computer via the serial cable (this should be done with the computer off) and download the simple program shown in Listing 1 into the PICAXE chip.

If you increase the logging interval to 10 seconds by changing line 5 to 'wait 10', you can keep a continuous seismograph record for up to a week. You could also hang a piezo transducer off the PICAXE and add an 'Alarm' loop to the program to warn you if b1 exceeds a certain value.

Once the program is loaded and running in the PICAXE-08M (check

## Tectonic Plates, Earthquake Waves & The Richter Scale

*"An earthquake is the way the Earth relieves its stress by transferring it to the people who live on it." – Dr Lucy Jones, USGS.*

EARTHQUAKES occur when adjacent blocks of the Earth's crust slide past each other along a fracture we call a fault line.

Most active faults are located near the boundaries of the Earth's tectonic plates. These plates move in several ways: (1) they can slide past each other; (2) they can move away from each other (diverge); or (3) they can move towards each other (converge).

For example, the west coast of New Zealand's South Island – which is at the eastern edge of the Australian-Indian plate – moves north along the Alpine Fault. This movement is relative to the eastern side of the island, which is part of the Pacific plate. This area experiences several magnitude five quakes every year, as well as much larger but less frequent earthquakes.

Plate divergence generally occurs at mid-ocean ridges, such as the Atlantic's, which rises above sea-level to form Iceland's central rift valley. Convergence occurs at 'subduction zones' like the one that caused Aceh's Boxing Day earthquake. Here, the northern edge of the Australian-Indian plate is descending under Indonesia, which is part of the Eurasian Plate.

While most active faults are located near plate margins, about 10% of active faults occur well away from the plate margins. The earthquakes generated in these locations are known as intra-plate earthquakes and are mostly thought to occur either as a response to stress transmitted through the plate from its interaction with adjacent plates or from thermal equilibration, which can cause contraction as the plate cools down or expansion as the plate warms up. The Australian Northern Territory's Tennant Creek fault is a world-famous example of one of these intra-plate structures and generates a number of generally small earthquakes each year.

Several types of vibrations are generated as blocks of rock grind past each other during an earthquake and these propagate around and through the planet as different types of earthquake waves. The fastest (and the first to arrive) are 'Primary' or P-waves, which are longitudinal compressional waves that propagate at speeds of 1.5-8km/s (depending on rock density). The next fastest are the 'Secondary' or S-waves which are shear waves (or transverse waves) and these propagate at speeds of about 3.2-4.8km/s.

Both P and S-waves move through the body of the planet and are refracted and reflected as they encounter rock density and composition changes. However, S-waves cannot propagate through the liquid part of the Earth's core. In fact, it was by examining the geographic pattern of P-waves and S-waves that led to the formulation of the core-mantle-crust model of the Earth.

The slowest waves are surface waves, which propagate at speeds of about 2-5km/s. There are two types of surface waves: Rayleigh and Love (L) waves. It's the shear and surface waves that generally cause the damage associated with earthquakes.

By measuring the time gap between the arrival of the P and S waves, it's possible to calculate how far away the earthquake was from the seismograph. This is roughly 500km for every minute between their arrival. The location of the epicentre is determined by a form of 'triangulation'.

To do this, a circle corresponding to the calculated distance is drawn around at least three different seismograph locations on a map of the region. Where the circles intersect is the likely epicentre. Most earthquakes occur at depths of less than 100km.

P-waves have higher frequencies and are best detected with a 'Short Period (one second or less) Vertical Seismograph', while S, L and Rayleigh waves have lower frequencies and are best detected by a 'Long Period (10 seconds or longer) Seismograph', such as the design described here. Professional seismic stations have short, long and wide-band seismographs mounted north-south, east-west and also vertically, with both low and high-sensitivity detectors.

Analysis and filtering of the seismic patterns allows the arrival of each type of wave to be determined from the mixture of P, S, L and Rayleigh waves, reflections (PP and SS waves), refracted waves and alternative path surface waves. Our seismograph, with a one-second (or 10 second) sample rate, will probably only detect S-waves and the much larger displacement L-waves and Rayleigh waves. If you live very close to the action, such as in New Zealand or Papua New Guinea, you might also detect P-waves.

The Richter value, devised by Charles Richter in 1935, is basically a logarithmic measuring scale. It's calculated according to the largest ground motion waves that are detected 100km from the epicentre of the earthquake. Because the scale is logarithmic, a magnitude 7 earthquake has 10 times the ground motion (and more than 30 times the energy) of a magnitude 6 quake.

The Aceh Earthquake measured 9.0 on the Richter scale and released many thousands of times more energy than the 5.6 Newcastle earthquake of 1989.

by looking at the 'debug' screen), you must close down the PICAXE Programming Editor to free the COM Port, so that the StampPlot Lite program can use it. StampPlot Lite is available free from **www.selmaware.com**

### Using StampPlot Lite

StampPlot Lite is the logging program. Once it's installed, you need to carry out the following steps:

(1) Set the COM port so that it's the same as the port that connects to the PICAXE.

(2) Change the Baud rate to 4800.

(3) Click on 'Connect' and 'Plot Data' – the program should immediately begin to graph the values sent by the PICAXE-08M. You can test this by blowing on the bar from a distance of about one metre. Adjust the Sensitivity control (VR1) for

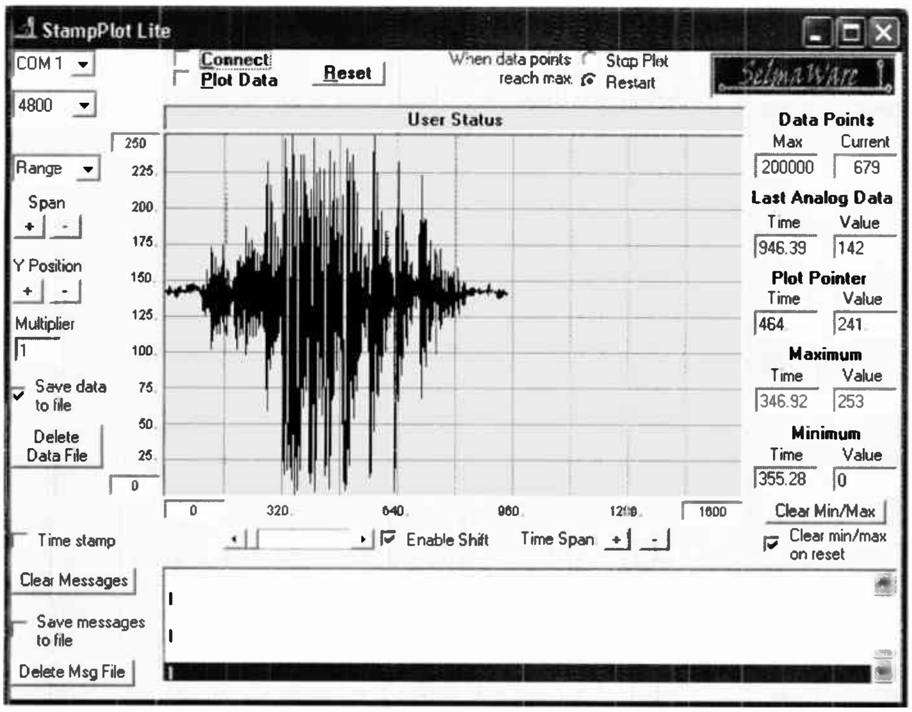



**Fig.3: this simulated plot of an earthquake was produced during final sensitivity tests of the seismograph. A gentle puff of air aimed towards the seismograph masses from two metres away produced the first 'earthquake' waves, while similar puffs from one metre gave the full scale deflection.**

## Program Listing 1

```
main:
 readadc10 4, b1      'makes an A-D conversion of the value at input 4 and sends to b1
 debug b1             'allows you to see the value at b1 on the Picaxe debug screen
 sertxd (#b1,cr,lf)   'sends the value of b1 out to the StampPlot Lite program
 wait 1               'sets the time gap in seconds between readings
goto main             'makes the program loop back to the start
```

full-scale deflection. The 'action' near the bottom of the screen indicates that data is being collected.

(4) Set the maximum number of points to 200,000 or higher.

(5) A 'Time Span' of 400 seconds will show each swing of the bar during testing but increasing this to 25,600 will let you see most of a night's recording. The UK is normally a long way from the action and different types of earthquake waves will continue to arrive for more than an hour after a distant quake.

(6) Click on 'Save data to file' so the program saves the data as a .txt file.

(7) Click on 'Clear min/max on reset' and you will be able to see if any values have been detected that are significantly above the background line (ie, an earthquake) and when this occurred (approximately). If you deselect 'Connect' and 'Plot Data' to stop the recording, you can look back at stored parts of the graph by moving the bar next to 'Enable Shift'. The running graph can be seen on the screen and '.txt' values can be exported to Excel and graphed.

(8) Click on 'Time Stamp' so that Excel will show 'Time' on the graphs.

Good luck and I hope that the Earth moves for you. ***EPE***

*Acknowledgement: thanks to Dr Tom Hubble of the University of Sydney for his geological knowledge and neighbours Jo and Manfred for computing and design assistance.*

# READOUT

Email: editorial@wimborne.co.uk

**John Becker addresses some of the general points readers have raised. Have you anything interesting to say? Drop us a line!**

**All letters quoted here have previously been replied to directly.**

## WIN AN ATLAS LCR ANALYSER WORTH £79

An Atlas LCR Passive Component Analyser, kindly donated by Peak Electronic Design Ltd., will be awarded to the author of the *Letter Of The Month* each month.

The Atlas LCR automatically measures inductance from 1μH to 10H, capacitance from 1pF to 10,000μF and resistance from 1Ω to 2MΩ with a basic accuracy of 1%.

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## ★ LETTER OF THE MONTH ★

### SMT Rework

Dear EPE,

The email from Edward Chase (*Readout*, Aug '07) brings to mind my adventures on a naval base in the early 90s. Some training simulator equipment was under development, based on a VME-bus computer rack, and there were problems with an interface for which I was expensively scrambled to have a look and see what was going on.

VME has an unfortunate feature, in that one of the bus address signals is immediately adjacent to a −12V supply rail. Working with one of the processor cards on an extender (an adapter, which lets you have a card running while accessible outside the rack), I was quickly probing the signals with a scope and accidentally shorted the address signal to the −12V pin, which promptly blew every card plugged into the rack at the time (which included, fortunately, only the ones needed for my particular debugging, having taken the precaution of removing the others). Two out of three processor cards had address buffers fried, but I needed two cards minimum to make any further progress, and it was a weekend so there was no access to spares or any tools I didn't have with me, and neither were the cards of my own company's manufacture.

I managed to trace the address signal from the edge connector to the relevant address buffer chip, which (woe-of-woes) was a 20-pin SOIC (i.e. surface mount, 0.05in lead pitch), but there were also lots more of these particular buffers used on the card. If I could do it with the tools to hand, I realised I could steal a good buffer from one of the dead cards to repair the other dead card, and along with the remaining live card be able to carry on the investigation – except that the tools to hand were no more than normal pliers, cutters, screwdrivers, and a 15W soldering iron.

It has to be said that SOIC is probably the least difficult SMT package to deal with. I took a trip out to a local shop and bought a pack of wedding-dress pins (very fine, still in my tool kit to this day and also useful for probing a wire through its insulation), sacrificed a plastic biro as a handle and melted a pin into it, forming a tiny hook on the end of the pin. With the hook and soldering iron and a little extra solder to wet the joints, I worked my way around a dead chip lifting each lead in turn (practice) to get the chip off, then I did the same with a presumed good chip on the other dead board. The pins on the good chip, and the solder pads where it was to go, had to be levelled off by removing as much solder as possible with desoldering braid, and finally I was able to tack the chip into place and solder all round.

I'm proud to say it worked (though less proud of why I had to do it). I completed my debugging, and the maintenance people had a load of kit to send off for repair on the following Monday.

Bear in mind that was SOIC – 0.05-in lead pitch. Edward Chase is asking about 0.5mm (0.02-in)! No, that's not a mistake, they do exist (and even smaller). Normal workshop methods for hand assembly of SMT use hot air, and solder paste rather than wire. On the production line, the bare PCB has solder paste screen-printed onto it through a mask corresponding to the solder pads only, the components are placed onto the pads (and held by the stickiness of the solder paste), then the whole lot goes through an infra-red reflow oven (which melts the solder and completes the joints).

The biggest problem with hand assembly is stopping excess solder bridging the incredibly narrow gaps between leads, or getting rid of it if it does. The really fine-pitched devices rely on the solder mask (a coating on the PCB that repels solder) to 'discourage' the melted solder going where it shouldn't, and only the minimum required amount of solder.

Lead-free solder is another issue. The higher temperatures required (for less time to avoid component and PCB damage) is tricky for hand assembly of conventional components, let alone SMT.

I'm not saying it can't be done, but Edward has to make a judgement whether there is anything to lose in a failed attempt (that might become irreparable in the process). Unless he has access to a professional SMT rework workstation, I would take on 0.05in, and maybe even 1mm, as long as the pins are easily accessible, but I would draw the line there and anticipate a long job. Of course, a lot of SMT chips these days have connections obscured under the device itself, and you might as well give up and go home.

Complete disassembly of an SMT board is simplicity itself: shine a hot-air paint stripper at it for a few moments, turn upside down and give it a sharp tap!

PS: If selected as Letter of the Month, donate to charity (yes, it's me again)!

**Ken Wood,**
**via email**

*Thanks for those observations Ken. I trust Edward and others will find them useful.*

*Yes, you are LOM again – so thank you too for that generous offer. I leave it to HQ to decide which charity benefits.*

### Techno Talk and CFLs

Dear EPE,

I would disagree in part with *Techno Talk* Sept '07:

'Standard CFL bulbs do not work with existing dimmer switches', true, but no longer true. Versions are available.

'30 seconds and four minutes to reach full brightness', generally not true, although I could accept two minutes. Newer designs are faster and getting better all the time.

'Lamp life is reduced when CFLs are switched on and off frequently.' True of all lamps with the possible exception of LEDs. In this case there are other components within the 'driver', as the trade calls it, which may be affected – I've no data on this, however.

'Rapid death if they are allowed to overheat', true of all lamps, including LEDs.

'CFLs produce light in a narrow frequency range'. No, CFLs are triphosphor lamps with a colour rendering index of around 85%. The ordinary house lamp is indeed 100%, but I challenge anyone to notice a practical difference. However, the colour appearance is different, which is not the same as showing up colours.

'The future is SSL – solid-state lighting' – agreed!

Otherwise, I generally agree with this article. Philips are (privately) very confident about their LED technology, which should see real products early 2008. Osram are already there, but not yet with practical replacements.

**Dave Geary,**
**via email.**

*Dave thanks for that. We welcome your article on* Banning the Bulb, *elsewhere in this issue. Mark Nelson responds –*

Thanks John for allowing me to comment. Dave Geary and I are not in major disagreement.

'Standard CFLs ... dimmer switches' – that's precisely why I used the word 'standard'. Versions are indeed 'becoming available ... that will', but that still does not apply to the standard ones you buy in the shops now.

Regarding brightness, Dave refers to newer ones and getting better. I accept this but I am referring to ones that I bought ten years ago and will happily send him as proof! I am happy to accept the delayed warm-up in return for longer life.

'Rapid death for all lamps' – OK, but I find them even less tolerant of confined shades.

'CFL frequency range' – I should have expressed myself more carefully but as Dave admits the colour appearance is different, he supports the point I made quite nicely. See also the top two graphs at **www.darksky.org/images/light_spec**, which illustrate clearly that the light quality is different.

**Mark Nelson,**
**via email**

## CFLs

Dear EPE,

I received my June issue of *EPE* only recently. Nevertheless, I would like to comment on your editorial in that issue on compact fluorescent lamps.

First, it isn't exactly correct to describe the announcement in Australia as a 'ruling'. It was an announcement by one cabinet minister at one press conference of a plan to introduce this as a government policy. Since then, our government has been spectacularly quiet about the idea.

Probably because...

Second, it seems that the relevant cabinet minister didn't only forget to do his technical homework, he also forgot to do his legal homework. Our political system here is more like that in America than that in Britain. Our federal government has a lot of power, but its power is not unlimited and for some issues, the power is with the State governments, not with the Federal government. I expect this initiative to progress here at the speed of a thousand snails.

You and/or your readers might be interested in my experience with CFLs. When these first became available, in the early 1990s, partly just because I like to be modern, I embraced them enthusiastically and ruthlessly converted almost every light to use a CFL, even to the extent of replacing some quite expensive 'pride and joy' light fittings when I discovered that they couldn't support the weight or the size of the CFLs.

While some CFLs worked well, I encountered many problems. The first generation lamps were not anywhere near as reliable as the advertising claimed. It is significant that some were withdrawn promptly from the market and became unavailable.

For a while, the market was split. It became possible to buy reasonably reliable lamps for a reasonable price, but price was a poor indicator of reliability and about the only simple purchasing strategy was: 'cheap lamps are almost certain to be rubbish; expensive lamps are not certain to be worth the price; it is important to buy only one, test it, and if it is still working next year, and still available next year, it might be safe to buy some more of them'.

Clearly, this is a cumbersome strategy for buying something as simple and commonplace as a light bulb. Other problems include:

Your advice that normal CFLs are not dimmable is honest and accurate. I notice that some pro-CFL lobbyists claim that dimmable CFLs are available. This is true-ish, but only true-ish. The CFLs that work with dimmers must be special lamps, need special dimmers, and importantly, need an electrician to visit to install special wiring and special light fittings. Once the wiring has been converted to use a dimmable CFL, it can't be used with anything other than a dimmable CFL. Dimmable CFLs are so different from what most people expect them to be that we probably need to invent a different word or phrase, perhaps 'dimmable' for the familiar and 'variable intensity' for CFLs.

A couple of friends have installed normal CFLs in circuits with normal dimmers. They promise that they always leave the dimmer set to full brightness, but their CFLs are spectacularly unreliable, and sometimes fail within a couple of months. I haven't investigated thoroughly, but I suspect that even at full brightness, the dimmer needs a few volts itself and delivers a voltage to the CFL that is sufficiently different from what it expects that some internal component is overstressed. A peek inside the base of a CFL reveals that the electronics are very definitely designed to 'domestic' standards, and even under ideal conditions totter on the brink of their stress limits.

Maybe I'm just fussy, but most styles look industrial and ugly. The current fashion for 'olde worlde' light fittings compounds this problem.

In some circuits, some modern lamps glow in the dark. It probably isn't a hazard, but it is certainly eerie and annoying. Probably, the next generation will include an extra component to fix this.

The colour temperature is not well explained, even less well understood, and poorly standardized. In most shops, these things are sold by shop assistants, not by physicists or photographers, and even simple questions can provide minutes of amusement and entertainment as shop assistants struggle to pretend that they know all about these volty and ampy thingies, usually revealing that they'd be much happier in the gardening section of the store.

The market has not improved and if anything, is worse now than a few years ago. While some prices have tumbled, rubbish is commonplace and buying a lamp worth its price is very much a 'lucky dip'. Even the longish life becomes part of the problem; if I believed in mysticism, I'd believe that the lamps know when I throw the receipt into the rubbish; pine for it, and fail within a few days so that they can join it.

Currently, I regard CFLs as 'too temperamental to be worth the trouble', and I am gradually converting most of my lights back to a variety of simple incandescent lamps. Although some of these are also rubbish, at least they are inexpensive rubbish.

**Keith Anderson,**
**Kingston, Tasmania,**
**via email**

*Keith, we're sorry to hear of your problematic experience with these lamps. Perhaps the newer products Dave Geary speaks of in his article on the subject elsewhere in this issue may prove more reliable to you.*

## Disappointed programmer

Dear EPE,

Having received *EPE* and *PE* since the early 70's I am now beginning to regret my renewal for the next two years. The reason is simple, PICs! I've followed John's excellent *PIC Tutorials* V1 and V2 of which I understood every word, and that includes all his various projects published since. From this experience I even managed to program some of my own projects.

However, since the time some readers versed in C cajoled *EPE* to take it up, I rarely understand any of the writers who followed with their discussions. Not only has no one bothered to tackle C for beginners, but the present PIC writers sometimes bandy the buzz words without providing a glossary. What is $I^2C$, SPI, bit banging or a bit-bashed USART, older directives, Boren bits, the LPT1OSC config bit, Bit PBADEN, capture mode. I could go on but it seems like one particular author (obviously an expert and very enthusiastic about his subject) is in a hurry to cover a lot of ground in minimum time but his erudition lost me a year ago because he deals with PIC subjects outside the bounds of my own experience.

Now I am aware from *EPE Chat Zone* that many readers are in the 'trade' and no doubt understand it all, or exactly where it fits any gaps in their own knowledge, or alternatively have means of reference. However, I am sure there must be many more readers like myself who are 'lone workers' with no one to refer to other than the Microchip website (run by experts for other experts). Incidentally, while having a moan, the only thing I learned about *Mechatronics* was how to spell it!

**Pat Alley,**
**via email**

*I sent Pat's comments on to Mike Hibbett, who is the author providing* EPE *readers with more information on using C with PICs, and other aspects of PIC programming and use. Mike is a professional software writer, well versed in different methods for writing PIC software code. Personally, I have great respect for his knowledge, and have been learning much from what he has written for* EPE. *He replies:*

I appreciate the comments, which are probably as a result of the attempt I am making to satisfy a wide range of reader's skills. So for example, one month I might cover 'how to read datasheets', and choose the terminology accordingly, and then another month discuss a very advanced topic (such as the 1-wire bus system this month).

I'll do my best to give a more reasonable split in subject complexity in the future, but if there are any particular subjects that readers would like explained from a beginner's view point I would be very interested to hear – I'm always interested in new ideas for subjects!

**Mike Hibbett,**
**via email**

*Pat, there is also the additional fact that it is not necessary to know C in order to program PICs, as you have already discovered through my* PIC Tutorials. *But I understand the desire of readers to know about C for PICs when they may already be partly familiar with C, but not necessarily in the PIC context.*

*Personally, I have a vague familiarity with using C, but wish to go on programming PICs through the assembly language route and am unlikely to change to C. I acknowledge that there will be many who disagree with my decision.*

*Regarding the terms you mention, most are covered in the datasheets for the PICs concerned. The intention of* PIC 'n Mix *and many other PIC-related articles is not to give an in depth view of a particular PIC, and it is expected that readers who are interested in that PIC will have already obtained a free datasheet for it from the Microchip website at:* ***www.microchip.com***.

# Net Work

**Alan Winstanley**

## First steps in broadband

A friend who works from home asked for recommendations for a broadband supplier, as they wanted to adopt Internet access for their new business. The bewildering array of choices made it a difficult question to answer. First, the availability of ADSL (asymmetric digital subscriber line) broadband depends on whether the local phone exchange is equipped to provide it, and performance then depends on the distance the signal travels in terms of copper wire miles, poor connections and the quality of the wiring.

Much has been highlighted recently about the unfair marketing practices of broadband suppliers, especially about adverts with headline-grabbing speeds of 'up to' 8Mbps (megabits per second), when in reality such speeds are often impossible to achieve due to the limiting factors of distance, congestion and line quality.

Whether buying broadband as a new customer, or upgrading an existing service, the first thing to be aware of is the disclaimer that performance is subject to practical line tests after you place an order, and second, no ISP is likely to guarantee the transmission rate that you will actually experience. Websites such as Virgin Media's broadband checker **http://broadbandchecker.co.uk/** indicate the likely availability in your postcode area, and comparison websites, including **www.broadbandchoices.co.uk** and **www.uswitch.com,** offer alternatives for you to choose from.

Broadband suppliers have their own merits – including cost, locally-based services, free or premium technical support or free hardware. Sometimes, an introductory discount is available for the first few months. Some areas have cable access, so the choice of supplier is restricted, but for most of us broadband means ADSL, delivered by your choice of ISP through your BT phone line. In rural areas, perhaps consider satellite or find out if a local specialist service is available. One example is the wireless mesh service offered by the award-winning company South Witham Broadband (**www.wireless.southwitham.net/**), which was built by local people to deliver broadband to their villages.

There was a time when AOL (**www.aol.co.uk/.com**) compact disks were found on every computer magazine (and in every letterbox – see **www.nomoreaolcds.com**). AOL is firmly a family-orientated service that uses proprietary software for mail and browsing: I know of some AOL users who were aghast at the prospect of firing up Internet Explorer or Outlook Express on their AOL connection!

AOL encapsulates its customers in a safe environment away from the wild west of the Internet. Most other ISPs just provide raw broadband connections and associated services, such as anti-spam and antivirus, and they just leave you, your wits and your computer to fend for themselves out on the Internet.

## The need for speed

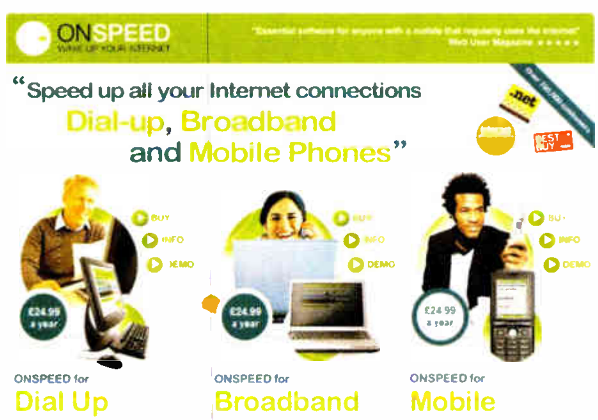
Casual users will be happy with 2Mbps speeds but most will probably opt for a rate of (up to) 8Mbps. The cheapest packages may have a monthly ceiling of data transfer but many tariff packages have no capped usage restrictions, subject to their interpretation of 'fair use' – your connection may be throttled back or even suspended altogether, if you regularly overdo your downloads.

ISPs may tempt new customers with a **free modem** or **router**: however, as mentioned before in *Net Work*, only a router properly set up for security should be considered good enough. A single-port straight-through modem is insecure and is best discarded. Wireless networks should also be set up robustly for security, to prevent unauthorised use of your broadband by your neighbours or 'drive-by' users. Setting up a secure wireless network may require specialist help, and an hour's expert labour might be money well spent. PC World's The Tech Guys charge from £69.99 (**www.thetechguys.com/**) for this.

Another consideration might be the sending of **own domain-name mail**: some ISPs (notably BT) suffer a major malfunction when their customers send mail as 'From: *user@myowndomain.co.uk*.' BT has been known to block legitimate mail because they disputed the domain name details.

**Outbound mailservers** can be slow or busy especially if networks are overloaded with spam. Rather than rely on the broadband supplier's SMTP server, the classic workaround for sending outbound (SMTP) mail is to use an authenticated third party mailservice, notably Authsmtp (**www.authsmtp.net**), which is a robust low-cost service that removes the dependence on your ISP's SMTP servers. This is also relevant if you intend to send out bulk Email campaigns regularly. In June 2007 Tiscali users found to their cost that relying on an ISP's own SMTP service was not always wise, as there was an outage lasting for about a week.

The foregoing factors are some key points to consider when shopping around for an ISP. It should not be forgotten that some Internet users have very low usage requirements and are happy with 56k dial-up access for checking email or for occasional web surfing, paying say 5p per call added to their BT phone bill. It may well pay to examine the benefits of always-on high speed broadband though: even if it costs more. For some users the time saved over waiting for dial-up can make broadband worthwhile.




Onspeed offers to accelerate Internet speeds for dial-up, broadband and mobile users, using a patented file-type compression technology

Both dial-up and broadband users could gain a useful increase in speed by using the download accelerator service from Onspeed (**www.on speed.com**). For a flat rate of £24.99 or €39.99 a year, Onspeed promises a tenfold increase for dial-up and five times increase for broadband users. Web pages, emails and some file types are compressed 'on the fly' using Onspeed's patented server-based technologies, and then uncompressed on the client's PC using Onspeed's software. It is claimed to work in most countries apart from certain African or Middle Eastern areas.

Next month some of the current anti-virus software packages are outlined. You can email Alan at: **alan@epemag. demon.co.uk**

# PCB SERVICE

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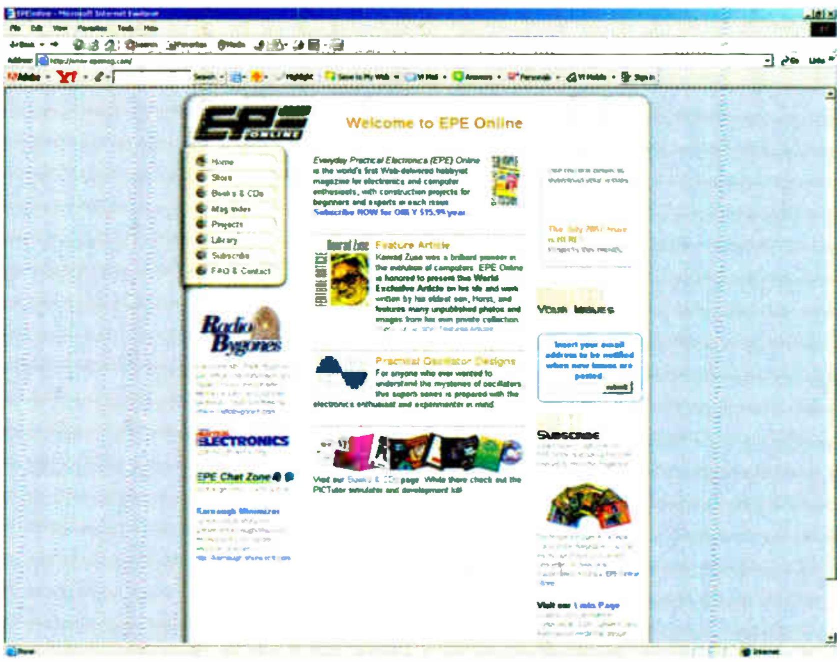

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